#773

HEAO-1

A-2 NEP DATABASE

A-2 SEP DATABASE

A-2 MAP DATABASE

A-2 MAX DATABASE

A-2 FCUT TIMED DATABASE

A-2 SORTED FCUT SOURCE DATABASE

A-2 FCUT BACKGROUND DATABASE

77-075A-02J,02k,02M,02N,02O,

02P,02Q

HEAO-1

A-2 NEP DATABASE

77-075A-02J

This data set consists of 23 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on an IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101192	C-032119	66	08/14/77 - 09/06/77
D-101193	C-032120	61	09/07/77 - 09/24/77
D-101194	C-032121	40	09/25/77 - 10/12/77
D-101195	C-032122	45	10/13/77 - 10/30/77
D-101196	C-032123	47	10/31/77 - 11/17/77
D-101197	C-032124	51	11/18/77 - 12/07/77
D-101198	C-032125	49	12/08/77 - 12/28/77
D-101199	C-032126	41	12/29/77 - 01/15/78
D-101200	C-032127	45	01/16/78 - 02/03/78
D-101201	C-032128	51	02/04/78 - 02/25/78
D-101202	C-032129	93	02/26/78 - 04/04/78
D-101203	C-032130	100	04/05/78 - 05/16/78
D-101204	C-032131	74	05/17/78 - 06/21/78
D-101205	C-032132	76	06/22/78 - 07/27/78
D-101206	C-032133	38	07/28/78 - 08/14/78
D-101207	C-032134	46	08/15/78 - 09/01/78
D-101208	C-032135	29	09/02/78 - 09/13/78
D-101209	C-032136	60	09/14/78 - 10/07/78
D-101210	C-032137	25	10/08/78 - 10/15/78
D-101211	C-032138	32	10/16/78 - 10/27/78
D-101212	C-032139	58	10/28/78 - 11/20/78
D-101213	C-032140	59	11/21/78 - 12/14/78
D-101214	C-032141	45	12/15/78 - 01/07/79

USER'S GUIDE

to the

HEAO A-2 DATA ANALYSIS SYSTEM

Laboratory for High Energy Astrophysics
Goddard Space Flight Center
Greenbelt, Maryland

June 23, 1988

TABLE OF CONTENTS

MUST BE WORKED ON

APP7 - 1 GETPHAC EXAMPLE

APP7 - 3 LIST OF MATRIX FILES SAME AS 7.5

WORK ON

MORE DETAILS

MUST BE WORKED ON

1.0 INTRODUCTION

The High Energy Astrophysical Observatory (HEAO-1) satellite was launched on August 12, 1977 from the NASA/Kennedy Space Flight Center. In scanning mode, the satellite was spinning slowly, with a period of roughly 33 minutes about an axis pointed within a degree of the sun. Every twelve hours or so, this scan axis was increased by 0.5 degrees, to keep it pointed at the sun. After six months, it pointed 180 degrees from its original orientation, and the entire sky had been scanned. After about 100 days, the scanning was periodically interrupted to point the satellite at particular objects of interest. The satellite alternated between scanning and pointing, with increasing frequency of pointings, until January 9, 1979, when the gas used to control the attitude of the spacecraft ran out. Systems were then shut down, and HEAO-1 drifted in a decaying orbit until March of 1979, when it burned up re-entering the atmosphere.

1.1 PURPOSE AND SCOPE OF THE GUIDE

The purpose of this User's Guide is to allow the user to become familiar quickly and easily with the procedures needed to utilize the HEAO A-2 data analysis system and its associated computers and data bases. Two computers are currently being used in conjunction with the HEAO A-2 data analysis in the Laboratory for High Energy Astrophysics (LHEA) at Goddard Space Flight Center: an IBM 3081 and a MicroVAX II. The IBM 3081 is located in Building 1, Room 6; the MicroVAX II is located in Building 2, Room S214.

The IBM 3081 computer controls access to the primary A-2 database, which consists of tapes known as "MAX" tapes, and several secondary databases. The user may access these databases to generate output tapes for use with the analysis programs on the MicroVAX II.

The MicroVAX II computer stores all of the software for the HEAO A-2 data analysis system. Additionally, the DSDISK database is stored on the MicroVAX disk. The MicroVAX computer provides interactive graphic capabilities used in support of scientific data analysis activities and prompts the user to enter data. The MicroVAX computer is managed by Mary Ann Esfandiari at 286-8735.

More detailed descriptions of the computer systems is located in Chapter 3, **COMPUTER SYSTEMS.**

This guide is designed to explain the procedures to follow to logon and logoff of each computer system, locate and run analysis programs, acquire the desired data, operate the computers, and suggest sources of assistance. More complicated programs requiring some explanation regarding the necessary input information will have both a section dealing with the discussion of the options of the program, and a section displaying an example execution of the program. In the discussion of the input of information section, the main program prompts begin at the left hand margin. To indicate branching from prompts as a consequence of the user's specific responses, the possible branch prompts are indented from the left margin. Simpler programs combine the discussion

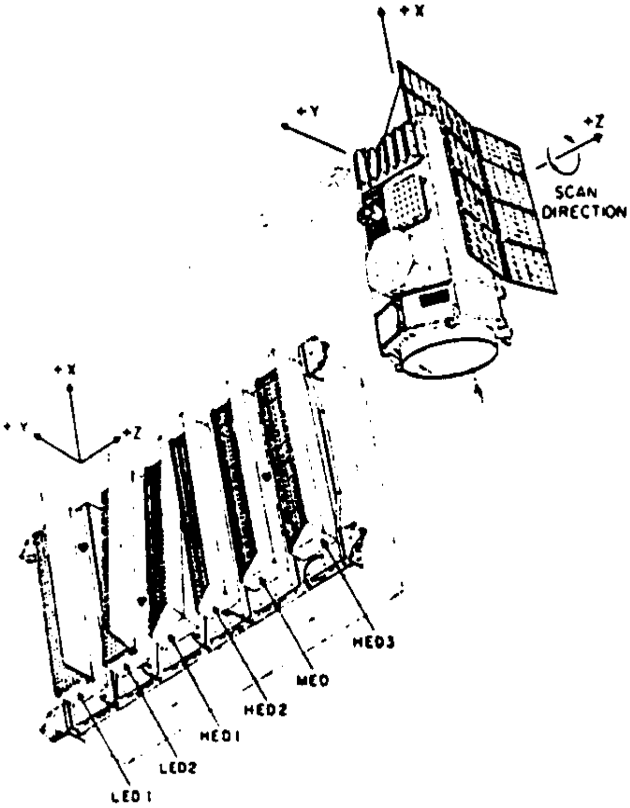


Fig. 1. Configuration of the six detectors within the Cosmic X-Ray (A-2) Experiment and its position in the HEAO-1 observatory. The three axes of the spacecraft are labeled and the sense of the rotation is shown.

Figure 1

2.0 A BRIEF DESCRIPTION OF THE HEAO A-2 EXPERIMENT

The HEAO Cosmic X-Ray Experiment (HEAO A-2) was conducted aboard the HEAO-1 satellite from August 12, 1977 through January 9, 1979. The experiment consisted of three types of multi-anode, multi-layer, collimated, gas proportional counters and their associated electronics. The detectors are designated: HED (high energy detector) for xenon-filled counters, covering the energy range 2.5-60 keV; MED (medium energy detector) for the argon-filled counter, covering the band 1.2-20 keV; and LED (low energy detector) for the thin window, propane-filled, flow counters covering the range 0.15-3 keV. The configuration of the six detectors (LED 1, LED 2, HED 1, HED 2, MED and HED 3) within the HEAO-1 observatory is shown in Figure 1 which follows this chapter. A system for analyzing the MED and HED data is available at Goddard Space Flight Center and is described in this guide.

In the HEAO A-2 experiment, time is measured using calendar days of 1977. For example, the first day of the experiment, 1977 August 12, is designated as Day 224, and the last day of the experiment, 1979 January 9, is designated as Day 739. The programs generally use days and milliseconds -- Day 731, Millisecond 02460000.

Examples of results of the A-2 data can be found in the following publications:

The Cosmic X-Ray Experiment Aboard the HEAO A-1, by R. Rothschild, et al., Space Science Instrumentation 4 (1979), p. 269-301, 0377-7936/79/0044-0269.

Observations of the Transient X-Ray Source 4U 0115+63, by L.A. Rose et al., Ap.J. 231, 919 (1979)

Additional information is available in the following publications:

HEAO 1 A-2 Experiment: The Configuration of the Hard X-Ray Detectors, by Dr. F. E. Marshall, September 19, 1983.

The HEAO A-2 Cosmic X-Ray Experiment Technical Manual, by R.E. Rothschild, 1977 (known as the "Yellow Book").

2.1 CHARACTERISTICS

Each of the A-2 detectors, described in Section 2.0, had a complete set of electronics, consisting of front end electronics, source encoder, data processing unit (DPU), test pulse generator detector command decoder, detector programmer, low voltage converter and high voltage converter. The front end electronics shaped and amplified the signal collected at a detector anode; the pulse first passed through a test pulse generator input section, and the sums were formed for the anti-coincidence circuit. The signals were then passed to a charge sensitive preamplifier, a filter network, and a bi-polar amplifier. Pulses were shaped to reduce dead time and microphonics. The output signal was sent to the heart of the analysis system, the source encoder. If one or more of the input signals exceeded a commandable threshold, processing began. Acceptable events were then Pulse Height Analyzed (PHA) into one of 128 energy channels.

Each detector consisted of a detector housing, a collimating system, three or four layers of wire grids, a grid cover, a thin window, and filling gas. An incident X-ray photon passed through the window to the gas volume and deposited its energy by photoionizing an atom of the filling gas. The detector electronics associated an energy and a time with each of the detected X-rays.

Each DPU had eight output ports which were read out via 8-bit words. The ports included a direct readout of pulse height data, accumulated pulse height histograms, and discovery scalar (count rates in broad energy channels) data. For both the pulse height histograms and discovery scalars, separate ports were used for the least significant bytes (LSBs) and the most significant bytes (MSBs) accumulated.

Commandable parameters included detector voltages, signal pulse thresholds, and data formatting quantities such as integration time, number and distribution of PHA channels, and telemetry rates for each detector. The Data Director, part of the Data Collection System, used format information stored in one of three memory banks. Two were fixed, read-only memories (ROM 1 and ROM 2); the third was a variable-format memory (RAM), versions of which could be sent from the ground. Data was taken sequentially from the addresses stored in the selected memory. The contents of the selected memory controlled how much of the data accumulated by each of the DPUs would be transmitted to the ground and recorded. It was important that the readout format stored in the current RAM/ROM match the data-taking format commanded from the ground.

More frequent readouts, containing less precise spectral information, were possible with rates known as Discovery Scalers. These were eight rates (four from large field-of-view data and four from small field-of-view data) accumulated in various combinations of spatial and spectral windows.

2.2 PERFORMANCE

The primary goal of the HEAO A-2 experiment was to provide a complete survey of the X-ray sky. An attempt was made to maintain the experiment in the same configuration as much as possible. Changes were occasionally made to the configuration as experience was gained in analyzing the data and particularly after the LEDs ran out of gas.

HEAO 1 was launched on August 12, 1977, Day 224 of 1977. The first week of operation was devoted to turning the detectors on and to calibrating their performance. The detectors gradually achieved long-term stability. On Day 232.04, the detectors' high voltage was changed to their normal state, where it remained for the remainder of the mission. Stability was achieved for the HEDs at Day 234.95; MED stability was achieved on Day 248.15.

2.3 VARIATIONS DURING THE MISSION

After stability was achieved by Day 248.15, there were very few variations during the mission. The variations which did occur are described in detail in ***HEAO 1 A-2 Experiment: The Configuration of the Hard X-Ray Detectors***, by Dr. F.E. Marshall, September 19, 1983. The more important changes are summarized below.

The Discovery Scaler definitions changed relatively often.

From Day 233.01 to Day 233.09, events in Window 1B were not processed by any of the HEDs as a calibration.

From Day 234.03 to Day 234.53, the bit to identify in which layer the X-ray occurred was dropped and the least significant bit of the pulse height was included for all detectors. After Day 304.93, the same processing occurred for all detectors except HED 2.

From Day 235.63 to 245.69, the MED did not process events in Window 2B because the PHA Window Layer 2 was inadvertently changed to not include Window 2B.

From Day 432 the LED heaters were on part of the time to increase the temperature of the LEDs. However, there was a sharp increase in temperature of all of the detectors.
From Day 510 the heater in the gas system was on part of the time to increase the temperature of the HEDs and MED. After Day 510 the temperatures were less stable.

From Day 645 until the end of the mission, HED 2 and HED 3 included only Layer 2 in the multiscalar rates.

3.0 COMPUTER SYSTEMS

The purpose of this chapter is to provide background and operational information concerning the various computer systems available to the laboratory. Currently, two different computers are used in conjunction with the HEAO A-2 analysis: an IBM 3081 and a MicroVAX II.

3.1 IBM 3081 SYSTEM CHARACTERISTICS

Call Nancy Laubenthal at 286-5778 to set up an account on the IBM 3081 computer system. The IBM 3081 is running two different operating systems: MVS and VM. The HEAO A-2 data analysis system is concerned only with the MVS operating system and the Time Sharing Option (TSO) command language which is used to interact with MVS. TSO allows the user to handle data, compile, link, edit, load and execute programs from a terminal. Additionally, the IBM has the Interactive System Productivity Facility/Program Development Facility which acts as a user friendly interface between the user and TSO.

3.1.1 Logon/Logoff Procedure on the IBM 3081 Computer

If the terminal in use is connected to a modem which will allow a choice for the operating system on the IBM, please put the switch on the MVS option, and proceed with the "logon screen". In the instance that the terminal is not connected to a modem, the user will need to "pass through" several screens in order to logon to the IBM MVS system. The first screen is the *VM NASA* welcome screen. To proceed to screen two, the user must depress the <CR> or the ENTER key. Screen two resembles the following:

Enter one of the following commands:

LOGON userid	*(Example: LOGON VMUSER1)*
DIAL userid	*(Example: DIAL VMUSER2)*
MSG userid message	*(Example: MSG VMUSER2 GOOD MORNING)*
LOGOFF	

The user must type "dial pvm" to proceed to screen three.

Screen three contains information on how to access a variety of systems. The user should either depress the PF1 key, or position the cursor in front of the S SCFMVS option. Screen four will appear and is the same as screen one -- the *VM NASA* welcome screen. Again, the user must depress the <CR> or the ENTER key. Screen five is the same as screen two:

Enter one of the following commands:

LOGON userid	*(Example: LOGON VMUSER1)*
DIAL userid	*(Example: DIAL VMUSER2)*
MSG userid message	*(Example: MSG VMUSER2 GOOD MORNING)*
LOGOFF	

The user should type "dial mvs" to proceed to the logon screen.

SCFMVS/NASA Space and Earth Sciences Computing Center - PLEASE LOGON

The user should now logon to the MVS system by typing:

`logon userid`

The *VS 2 REL 3.8G Time Sharing Option* screen will be displayed.

Respond to the password prompt, PASSWORD ===>, by entering your password.

A message stating that the logon procedure is in progress will be displayed, as well as current logon messages. When the final system line appears, the following prompt will be displayed:

Enter 3270 Model Number (2 (24x80), 3 (32x80), 4 (43x80), 5 (27x132)):

The user should enter 2.

You have no messages or data sets to receive.
READY

When the *READY* prompt appears, the user has successfully logged onto the IBM MVS system!

<u>To logoff of the system</u>:

`logoff`

The *SCFMVS/NASA Space and Earth Sciences Computing Center* screen will be displayed. The user must type four pound signs:

####

The screen which allows access to a variety of systems will appear. Press the PA1 key to display a system message concerning the PVM line being dropped. Finally, depress the <CR> or the ENTER key to return to the *VM NASA* welcome screen. The user has now successfully logged off of the IBM MVS system.

3.1.2 The ISPF/PDF Facility

ISPF/PDF is the Interactive System Productivity Facility/Program Development Facility on the IBM 3081 computer. It is a full screen menu-oriented facility designed to operate on IBM 3270 or 3290 style terminals. The facility can be invoked by typing SPF or PDF. ISPF/PDF uses menus or panels to allow the user to choose various options, to specify commands, to access TSO commands, and to display and edit information in full screen format. The facility also makes use of program function (PF) keys which have been equated to specific commands.

After typing SPF, the ISPF/PDF Primary Option Menu panel will be displayed and ready for input from the user. The ISPF/PDF options that the user is most likely to need are: "2" for EDIT, "6" for COMMAND and "8" for MORE. A tutorial option is also available ("T") for more detailed information on how to use the ISPF/PDF. Running the tutorial is suggested for the new user who intends to do any extensive amount of work on the IBM 3081.

The user should be aware of two handy functions: 1) the user can exit the ISPF/PDF from ANY panel by typing "=X" at the current input field, and 2) the user can jump from panel to panel by typing "=N" in the current input field, where "N" is the ISPF/PDF Primary Option Menu option number.

3.1.2.1 The ISPF/PDF EDIT Option

On the Edit-Entry Panel, the user can choose a dataset to edit by supplying the following information:

Project - USERID
Library - FNAME
Type - FTYPE
Member - FMEMBER (for partitioned data sets only)

An example of this type of data entry is as follows:

Project - XRMDD
Library - LIB
Type - CNTL
Member - REQSRC

If the dataset exists, it will be displayed and ready for the edit session. At this point it is useful to become familiar with the PF keys for use in conjunction with the Editor commands.

3.1.2.1.1 PF Key Definitions and Editor Commands

```
PF1  or PF13.......help
PF2  or PF14.......split (divides the screen)
PF3  or PF15.......end
PF4  or PF16.......return
PF5  or PF17.......rfind (repeat find)
PF6  or PF18.......rchange (repeat change)
PF7  or PF19.......up
PF8  or PF20.......down
PF9  or PF21.......swap (switch screens)
PF10 or PF22.......left
PF11 or PF23.......right
PF12 or PF24.......cursor home
```

The method of accessing these keys depends upon the specific terminal in use. If the "PF" is written on the face of the key, just use the key to access the function. If the "PF" is written on the front of the key, access the function by depressing the "ALT" and the "PF" keys simultaneously. If there is confusion with the PF key locations, the user can simply type the necessary command on the COMMAND ===> line at the top of the screen.

Some useful editing commands are the following which are entered on the COMMAND ===> line:

```
find stuff..............find the keyword "stuff"
change ostuff nstuff....change "ostuff" to "nstuff"
cancel..................quit this session and DO NOT SAVE
                        changes
save....................save all changes made thus far
end.....................quit this session and SAVE all
                        changes
```

In order to edit on specific lines of text, enter the following commands in the number field which is located to the left side of the screen:

```
i = insert a line after the current line
c = copy the current line
m = move the current line
b = insert a copy/move line before the current line
a = insert a copy/move line after the current line
```

Two handy editing keys are : â for inserting characters and ~~a~~ for deleting characters.

Please view the ISPF/PDF Tutorial on the Editor. The user can exit the EDIT Option and return to the main ISPF/PDF menu by typing END or using the PF16 key; this will automatically save the editing changes.

3.1.2.2 The ISPF/PDF COMMAND Option

The COMMAND option allows the user to input TSO commands while still running within the ISPF/PDF facility. This option is useful to submit jobs to the IBM

```
ENTER TSO COMMAND OR CLIST BELOW:

===> submit lib.cntl(reqsrc)
```

or to check on the status of jobs that have been submitted

```
===> show

 $HASP608 XRMDDGET PRT LOCAL      RUN LOCAL   PRIO 15 ANY
 $HASP608 XRMDD EXECUTING @ PRIO 15 S81A
 $HASP608 XRMDD AWAITING EXECUTION A     PRIO 11 ANY
 ***
```

Some other useful commands that can be entered from this panel are:

```
 lc = lists the catalogued datasets
 ql = displays the contents of a dataset
map = lists the characteristics of a dataset
```

The user can exit the COMMAND option and return to the main ISPF/PDF menu by typing END or using the PF16 key.

3.1.2.3 The ISPF/PDF MORE Option

The MORE option contains additional ISPF/PDF functions. In particular, the user will be interested in the MORE option "S" which is for the Spool Display and Search Facility. Choosing this option will allow the user to display program output and produce a line-printer copy of the output. Once option "S" has been chosen, another panel, SDSF Primary Option Menu, will be displayed. The user should input "H" as the command input; this option allows access to the held output queue which may resemble the following:

```
NP C JBNME TYPE JNUM DN CRDATE C FORM FCB RMT NODE TOT REC RNUM PRGRMMER
     XRMDDG JOB 3574  7 87.086 x  STD ****      1         550 5350 SSSPLT
```

Position the cursor under NP where one of the following can be entered:

S = Select = display the output listing
O = Output = print a hard copy of the output
P = Purge = delete the job from the held queue

If the user chose "S" in order to view the output, the user may move about the information using the same keys as were used in the Editor (PF19 - up, PF20 - down, PF22 - left and PF23 - right). The user can exit the MORE option and return to the main ISPF/PDF menu by typing RETURN or using the PF16 key.

3.1.3 Terminal Status Messages and Operational Notes

On occasion, status messages will be displayed on the bottom line of the user's terminal screen. It is useful to understand the meaning of many of these messages as problem determination and solving can be facilitated through the use of these warnings. The most common status messages are:

X Ⓞ	The host system is still working on the last task. Please wait for completion.
X ?+	The input was not understood by the host system. Press the RESET key to clear the problem.
X SYSTEM	The host system has locked the keyboard. Please wait for completion.
X -f	The host system does not recognize the function requested. Press the RESET key to clear the problem.
⚡ nnn	The link between the terminal and the host system is producing errors or is down, OR the host system is down. Contact the TAG at 286-9120.

The IBM style terminals do not scroll. When there is more than one screen-full of information to be displayed, a "***" symbol will appear. This is the signal to the user that there is more information to follow. When the user is ready, depress the ENTER key to continue. If the user wishes to cancel or abort an operation, the program access key (PA1) can be used.

3.2 MICROVAX II SYSTEM CHARACTERISTICS

Call Mary Ann Esfandiari at 286-8735 to set up an account on the MicroVAX II computer system which is running the VMS operating system. The user should observe no difference in the interaction and performance of the MicroVAX II in comparison to any other VAX, EXCEPT possibly in speed. For a more detailed and extensive description of the MicroVAX II system, please refer to *Introduction to the MicroVAX II* by Mary Ann Esfandiari.

3.2.1 Login/Logout Procedure on the MicroVAX II Computer

In order to login to the computer system:

Welcome to the MicroVMS V4.4

Username: username
Password: userpassword

Welcome to the MicroVMS V4.4

After some system messages, the system prompt *$* will appear. This indicates that the user has successfully logged into the system. In order to logout of the system:

$ logout

DELAPENA logged out at 18-NOV-1987 16:59:55.99

The user will receive some system accounting messages upon successful logout from the computer.

There are several ways to gain access to the MicroVAX computer: hardwired terminal, terminal server and a dial-up line. The hardwired terminal will have the Welcome Screen displayed, and the user should proceed with the above instructions. However, terminal server and dial-up line access require additional steps before arriving at the Welcome Screen.

3.2.1.1 Terminal Server

If the user's terminal is on a terminal server, when the terminal is turned on, the user will need to depress the <CR> or the ENTER key until the following message appears:

DECserver 100 Terminal Server V1.3 (BL15) - LAT V5.1

Enter username>

The user should enter any identifying name here as this is used strictly to identify a specific user with a specific port.

Local> c lheavx

Local -010- Connection to LHEAVX established as session 1.

At this point the user should arrive at the Welcome Screen.

<u>Logging off of the terminal server</u>:

After the user has logged off of the computer system as described in 3.2.1, the user will receive a message

Local -010- Session 1 disconnected from LHEAVX

Local> log

This has logged the user off of the terminal server.

3.2.1.2 Dial-up Line

If the user has a terminal connected to a dial-up data line (ROLM phone), when the terminal is turned on, the user will need to depress the <CR> or the ENTER key until the following appears:

CALL, DISPLAY OR MODIFY ?
c lheavx
CALLING #####
CALL COMPLETE

At this point the user must depress the <CR> or the ENTER key, and the Welcome Screen will appear.

<u>Logging off with the dial-up line</u>:

After the user has logged off of the computer system as described in 3.2.1, the user needs to depress the data button on the ROLM telephone twice.

3.2.1.3 Using the MacIntosh Plus as a Terminal Port

If the MacIntosh computer does not have the Versaterm-Pro emulation program stored on a hard disk, the user will need to insert the Versaterm-Pro disk into the computer and proceed with the VersaTerm panel.

The term "drag" is used in the description of using the MacIntosh with the accompanying mouse. Drag means to depress the mouse button and keep it depressed while moving the pointer around the screen until the desired option has been highlighted.

Use the mouse to position the pointer (cursor) arrow onto the *File* menu. Drag the mouse through the *File* options until the *open* command is highlighted and release the mouse button.

A display of the contents of the hard disk drive will appear. Click the mouse button twice in rapid succession on the VersaTerm icon. The VersaTerm panel will appear. Click the mouse button twice, in quick succession on the VersaTerm Pro icon.

The VersaTerm-Pro-DEC VT100 screen will be displayed. Position the pointer arrow onto the Phone command. Drag the mouse through the Phone options until LHEAVX is highlighted and release the mouse button.

CALL, DISPLAY OR MODIFY ?
C LHEAVX
CALLING #####
CALL COMPLETE

The user needs to depress the <CR> or the ENTER key until the Welcome Screen appears.

Logging off of the MacIntosh and the Versaterm-Pro Emulation:

After the user has logged off of the computer system as described in 3.2.1, the user needs to position the mouse at the File menu and drag the mouse through the File options. Release the mouse button when the Quit option is highlighted.

You are now completely disconnected from the MicroVAX and have terminated the Versaterm-Pro Emulation.

3.2.2 Filename Specification

A full filename on the VMS system is represented by:

node::device:[directory]file.extension;version

For example,

LHEAVX::$DISK1:[DELAPENA]radvel.for;99

In most instances the user will only specify the filename by file.extension (i.e., radvel.for) for files in user's directory, or by [directory]file.extension (i.e., [XRAY]radvel.for) for files in the [XRAY] directory. Default values will be supplied by the system for all missing parameters.

3.2.3 The MicroVAX VMS Editor -- EDT

In order to create a new file or to edit an existing file, the user should type the following:

$ edit/edt file.ext

where "file.ext" is either a name that the user has chosen (creating a new file), or the name of a file that currently exists in the directory file system (editing an existing file). Some examples of filenames are

radvel.for	fortran source file
spectra.dat	data file
manual.txt	text file

If a new file is being created, then

Input file does not exist
[EOB]

will be displayed on the terminal screen. The user can now begin inserting information to the file. If the user is editing an existing file, the beginning of the file will be displayed on the terminal screen.

The editing functions and cursor control can most easily be accessed by use of the Keypad Editing Keys. A representation of the keypad layout is included in this document at the end of this section. Line Mode commands of the editor are also available for additional editing flexibility. Please refer to the DEC EDT Manual for a thorough discussion of the editing functions.

To end an editing session, the user should depress the GOLD and COMMAND keys on the editing keypad simultaneously. The line

Command:

will appear at the bottom of the terminal screen. If the user wishes to save all of the changes made during this editing session, type EXIT and then depress the ENTER key on the editing keypad. The user will receive a message concerning the file that has just been edited and then be returned to the system monitor prompt *$*.

Command: exit <enter>
$DISK1:[DELAPENA]RADVEL.FOR;2 80 lines
$

If the user does **not** want to save any changes, type QUIT and depress the ENTER key. This will return the user to the system monitor prompt *$*.

Command: quit <enter>
$

3.2.3.1 Keypad Editing Keys

GOLD	help	fndnxt **FIND**	del l **UND L**
page **COMMAND**	sect **FILL**	append **REPLACE**	del w **UND W**
advance **BOTTOM**	backup **TOP**	cut **PASTE**	del c **UND C**
word **CHGCSE**	eol **DEL EOL**	char **SPECINS**	enter
line **OPEN LINE**		select **RESET**	**SUBS**

The **GOLD** key is used in the same manner as a "SHIFT" key. The **GOLD** key is depressed simultaneously with another editing key to access the boldface function of the specific key.

3.2.4 A Short List and Description of MicroVAX Commands

help	Invokes the help utility and provides list of useful commands
help command	Provides information concerning a specific command
show default	Displays information on the current working directory of the user
show users	Displays a list of the active users on the system
dir	Lists all files in the current directory
dir/date/size	Lists all files in the current directory supplemented by the date of creation of the file and the size of the file in blocks (512 bytes/block)
type file.ext	Prints (continuously) the contents of a file to the screen
type/page file.ext	Prints the contents of a file to the screen, one page (22 lines) at a time
set def [username]	Sets the default directory to username
copy infile.ext outfile.ext ..	Copies the contents of infile.ext to outfile.ext
rename infile.ext outfile.ext	Renames the file called infile.ext to outfile.ext
edit/edt file.ext	Invokes the editor. Please refer to the discussion of the editor in this document.
purge file.ext	Removes all old versions of file.ext
delete file.ext;ver	Removes the specified file. The version number is required.
run file	Runs executable file.exe
print file.ext	Prints the specified file on the lineprinter

3.2.5 Useful Control Sequences

In order to use a control sequence, the user must depress the CNTL key and the LETTER key at the same time.

ctrl z	Exits the current process neatly
ctrl y	Aborts the current process and returns to the system monitor (Panic stop)
ctrl s	Suspends the output to the terminal screen
ctrl q	Releases the output to the terminal screen (ctrl s and ctrl q are used as a set)
ctrl o	Sends the terminal output to a black hole (This is a toggle switch; subsequent uses will turn the terminal output on and off)
ctrl u	Clears the typing on the current line
ctrl r	Redisplays the current input line
ctrl t	Displays the current status of the user's account

Wildcards

Wildcards are used for the substitution of a single character or for a group of characters when referring to a VMS filename.

The percent symbol -- % -- is used in place of a single character in a specific position in a VMS filename. For example,

$ dir radve%.for	Listing of all files with one character (any character in the specified position.
$ dir radv%%.for	Listing of all files with two characters in the specified positions.

An asterisk symbol -- * -- is used in place of multiple characters in a VMS filename. For example,

$ radvel.*	Listing of all extensions of all files which begin with the characters "radvel.".
$ *.for	Listing of all fortran source files.

3.2.6 X-Ray Program Configuration

The X-Ray Astrophysics Group uses the [XRAY] account on the MicroVAX as a centralized location where the executable images of the general utility programs used in the HEAO A-2 data analysis are stored. In order to execute a program, the user would enter the RUN command, followed by the account_name and program_name. For example,

```
$ RUN [XRAY]HEAORB
```

The control libraries for the analysis programs are also located in the XRAY account. If you need to edit these sources, load modules and command files, or need to add new software, please consult Ms. Eunice Eng, the configuration manager.

The control libraries are organized as follows:

1. Executable Load Modules: $DISK1:[XRAY]program.EXE

2. The source library for a single software system has its own subdirectory.

   $DISK1:[XRAY.DSDISK]

3. Command files are stored in the source library. There are two command files: one to compile the sources and one to link the sources into an executable load module.

   $DISK1:[XRAY.DSDISK]COMPILE.COM
   $DISK1:[XRAY.DSDISK]LINK.COM

3.2.7 X-Ray Program Output

Output information from all HEAO A-2 data analysis programs is standardized to two forms: file.out and file.tmp. The "file.out" output contains diagnostic information including the date of the current analysis run, user input and perhaps data pertaining to the detector health; this output can be used for bookkeeping purposes and is setup in lineprinter format. The "file.tmp" output is critical in that it contains the information that is to be used as input to the next analysis program. It is an ascii file, but usually contains data without any documentation.

4.0 DATABASES

The main database for the HEAO A-2 data processing system resides on 6250 bpi tapes stored in the Science and Application Computing Center (SACC) tape library, and is accessed through the IBM 3081 computer in Building 1, Room 6. To facilitate scientific analysis, various subsets of the HEAO A-2 data have been extracted and reformatted into a set of secondary databases. Three of these subset databases are stored on 6250 bpi tapes and are accessed by the IBM 3081 computer; the remaining subset database resides on disk accessed by the MicroVAX computer in Building 2.

4.1 MAIN DATABASE -- MAX

The MAX database, generated by the FRAPPE program from the GSFC Information Processing Division (IPD) tapes, is the main database for the HEAO A-2 data processing system. It contains all satellite data, regardless of format or quality. However, the data has been reformatted from a telemetry stream order to a time order in which all data for a major frame have been accumulated into one tape record. The standard data formats (ROM 1, ROM 2, and RAM 1, RAM 9 and RAM 10) have been unpacked, and preliminary analyses have been performed to set flags for general data quality, engineering/science format, earth occultation (bare earth, or earth + 100 km), electron contamination, magnetic field direction, high voltage, and the South Atlantic/North Pacific Anomalies. The data for radical RAMs are only partially unpacked, and must be fully unpacked by individual analysis programs. For complete information on the MAX database format, refer to the *High Energy Astronomy Observatory Satellite-A (HEAO-A2) FRAPPE Program Description and Operator's Guide*. The MAX database tapes (density 4 -- 6250 bpi) are stored in the SACC IBM 3081 computer tape library in Building 1, Room 6; density 3 (1600 bpi) backup tapes are located in Building 2 for use with the MicroVAX II. It is strongly suggested that the user utilize the newer (more reliable) density 4 data tapes when it is necessary to access the main or any of the subset databases.

4.2 SUBSET DATABASES

The subset databases are used instead of MAX to increase the speed of data analysis by reducing the amount of data that must be examined. The four subset databases are: GETSRC, PHA, XRATES and DSDISK.

4.2.1 GETSRC Database

The GETSRC database contains MAX data records for a selected source position. No analysis has been performed except to include flags for clean, superclean, source in field-of-view, pointing mode and digital status in the output record. The *High Energy Astronomy Observatory Satellite-A (HEAO-A2) GETSRC Program Description and Operator's Guide* contains a detailed description of the tape format and information on generating this database.

The GETSRC database consists of four distinct "sub-databases". Three of these were the result of general production runs using all data for the

North Ecliptic Pole, South Ecliptic Pole (cone of 12 degrees centered on the Large Magellanic Cloud), and Galactic Plane (+/- 15 degrees) regions of the sky. The fourth is the result of "special request" runs for specified sources or regions of the sky. All tapes are density 3 (1600 bpi) to allow for their use on the MicroVAX and are retained in Building 2. A new 1600/6250 bpi tape drive has been added to the MicroVAX system, and therefore, 6250 bpi (density 4) output tapes may be generated for use on the MicroVAX.

4.2.2 PHA Database

The PHA database contains a complete set of PHA data along with limited discovery scalar data, the digital status, data flags (including flags for clean and superclean data), source in field-of-view, pointing mode, electron contamination, earth occultation, and the position of the moon for each major frame. Only major frames in which at least one detector has useful data are included (most earth occulted data are excluded). PHA was generated from MAX data tapes using the SKYMAP program with the PHA tape option. *The High Energy Astronomy Observatory A-2 SKYMAP Program Description and Operator's Guide* contains a detailed description of the tape format and instructions for generating this database. A complete set of density 4 (6250 bpi) PHA tapes are retained in the SACC tape library in Building 1, with density 3 (1600 bpi) backup tapes in Building 2.

4.2.3 XRATES Database

The XRATES database is a condensed version of the MAX database and is similar to the PHA Database; however, the PHA data is replaced by a complete set of rates data. It was generated from the MAX data tapes by the SKYMAP program, using the XRATES tape option. The *High Energy Astronomy Observatory A-2 SKYMAP Program Description and Operator's Guide* contains detailed tape formats and instructions for generating this database. A complete set of density 4 (6250 bpi) XRATES tapes are retained in the SACC tape library in Building 1, with density 3 (1600 bpi) backup copies in Building 2.

4.2.4 DSDISK Database

The DSDISK database is a subset of the XRATES database; it contains only rates data. This database was generated by computer codes written by Dr. Frank Marshall. The DSDISK database on the MicroVAX resides in $DISK1[XRAY] and is named DSFET.D15 (for 1.5 degree field of view data) and DSFET.D30 (for 3.0 degree field of view data); it contains the full range of available data for the HEAO A-2 experiment spanning the time from 232.1 - 737.1.

4.2.5 Data Files Generated by Analysis Programs on the MicroVAX

The analysis software for the HEAO A-2 data resides on the MicroVAX II computer system. The software has been designed to be interactive with the user; prompting the user for the input information. All programs produce a "program.OUT" disk file (where "program" is the name of the current program in use). The ".OUT" disk file is in lineprinter format and provides documentation on the execution of the program. It can be printed using the PRINT command. Many programs also produce a second output disk file which can be used by subsequent analysis programs. Unless the program asks the user to supply the name of this file, it will be called "program.TMP". Normally, the user should rename this output file.

5.0 GETTING STARTED

After the new user has attained some familiarity with the overall description of the HEAO A-2 experiment, the databases and the computer systems, the user is ready to begin the analysis of data.

First, it is necessary to determine if the experiment has the type of data that the user desires for the object/region of interest. The user must determine when the source was observed. This time of observation is the key to the ROM/RAM configuration which is directly related to the type of data available at the time. In order to determine the time of observation for scanning data, use the SOURCE program (Section 10.2) which will provide a list of days that the desired source was in the experiment field of view. For pointing data, refer to the Point List or the First Look Analysis Program (FLAP) Book.

Second, with the time of observation determined, the user should consult the following tables (TABLE 1 and TABLE 2) as to the type of scanning data available at that time.

The following table describes the history of the standard RAMs.

TABLE 1

Day of Data	RAM in Use
232	Toggle between ROM 1 and ROM 2 every 32.8 minutes
239	Toggle between ROM 1 and RAM 1 every 32.8 minutes
449	RAM 10
522	RAM 9

TABLE 2

	Detector	PHA Data LSB	PHA Data MSB	Multiscalar Data
ROM 1				
	LED 1	10s	10s	none
	LED 2	10s	10s	none
	HED 1	10s	10s	none
	HED 2	10s	10s	none
	MED	10s	10s	none
	HED 3	10s	10s	none
ROM 2				
	LED 1	none	none	yes
	LED 2	none	none	yes
	HED 1	none	none	yes
	HED 2	none	none	yes
	MED	none	none	yes
	HED 3	none	none	yes

	Detector	PHA Data LSB	PHA Data MSB	Multiscalar Data
RAM 1				
	LED 1	40s	none	yes
	LED 2	40s	none	yes
	HED 1	40s	none	yes
	HED 2	40s	none	yes
	MED	40s	none	yes
	HED 3	40s	none	yes
RAM 10				
	LED 1	10s	40s	none
	LED 2	none	none	yes
	HED 1	10s	40s	none
	HED 2	none	none	yes
	MED	10s	40s	none
	HED 3	10s	40s	none
RAM 9				
	LED 1	none	none	none
	LED 2	none	none	none
	HED 1	10s	40s	yes
	HED 2	10s	none	none
	MED	10s	40s	yes
	HED 3	10s	40s	yes

ROMs used during the HEAO experiment were ROM 1 and ROM 2. The ROMs contained "hardwired" data collection instructions, and hence, the type of data collected by the ROMs could NOT be altered. There was also a RAM aboard the experiment which could be loaded with instructions from the ground and assigned a version number from 1 through 16. RAMs used during the HEAO experiment for scanning data collection were RAMs 1, 10 and 9, which are commonly referred to as the "standard RAMs".

The digital status of the experiment changed as the standard RAMs changed so that the detectors would accumulate pulse height histograms over the appropriate time. The experiment status (for short periods of interest) may be determined by running the HEAORB program on the MicroVAX computer (Section 10.1).

As the RAMs could be programmed as the project desired, there exists pointing data in non-standard formats; these are known as "radical RAMs" (RAMs > 10). These RAMs are not unique; the same RAM number was assigned to different RAM formats. The data in these formats is only partially unpacked and the user must consult Dr. Jean Swank at 286-6188 for assistance concerning the formation.

Lastly, the user needs to determine whether the satellite was able to detect the source and whether there were other, confusing sources in the field of view. For scanning data, use the following resources:

1. The LIST2 printout contains a list of the sources which should

be detected by the experiment as well as possible confusing sources.

2. The *HEAO A2 Catalogue of Pre-HEAO X-Ray Sources* contains graphs of counts/second versus scan angles for sources which were detected and displays other sources within the field of view.

3. The DSDISK program on the MicroVAX computer accumulates data for 25 degrees of scan angle during times when the source was in the experiment's field of view, and produces plots similar to those found in the above catalogue.

Scanning data may also be used to indicate whether a pointed source was found, and whether there were confusing sources. Scanning data may help the user to determine rates and spectra.

For further information on scanning data, refer to the paper, *HEAO 1 A-2 Experiment: The Configuration of the Hard X-Ray Detectors*, by Dr. F.E. Marshall, 19 September 1983.

For further information on pointing data, refer to the Point List.

APPENDIX 5

THE GETSRC PROGRAM

The GET SOURCE Program (GETSRC) performs the function of extracting data for a particular location in the sky. The program creates a condensed database containing only those records in which a chosen location in the sky was observed. Using the main HEAO A-2 database, MAX, as input, the GETSRC program produces up to four output tapes (one per chosen sky location), each containing the records of data in which the appropriate location in the sky was observed.

Requesting an existing GETSRC Tape

To request a GETSRC tape, complete a GETSRC Request Form and return it to Hwa-Ja Rhee or Michele De La Pena in Building 1, Room 262. A sample GETSRC Request Form is attached at the end of this section.

Generating a new GETSRC Tape

The user should complete a GETSRC Request Form (as indicated above) for bookkeeping purposes. As the GETSRC program accesses the HEAO A-2 main database MAX, the program must be run on the IBM computer system. Refer to Section 3.1.1 for logon instructions for the IBM MVS Operating System.

Preparing the Output Tape

Before submitting the job, you must first attain the necessary number of blank output tapes (1-4) by contacting either Jean Swank at 286-6188, or Frank Marshall at 286-5279. Next, attain a tape slot by contacting either Hwa-Ja Rhee at 286-3695, or Michele De La Pena at 286-2316. Submit the tape to the Tape Librarian who will put it in the appropriate slot in the IBM 3081 tape library, located in Building 1, Room 6. If it is a new, blank tape, the tape must be initialized and labelled.

Dataset Necessary to Initialize a Blank Tape

JCL: 'XRMDD.LIB.CNTL(LABEL)' (ascii file)

The IBM computer offers the use of a menu-oriented facility which allows the user to work within the IBM structure more easily. This facility is called the ISPF Program Development Facility and can be invoked by typing SPF (or PDF) after the READY prompt. The ISPF/PDF Primary Option Menu will appear, and the user should choose catagory 2 which is the option for the ISPF Editor. The Edit Entry Panel will be displayed.

Enter the dataset information into the ISPF Library as follows:

```
Project ===> XRMDD
Library ===> LIB
Type    ===> CNTL
Member  ===> LABEL
```

This dataset (full name of XRMDD.LIB.CNTL(LABEL)) contains the JCL required in order to submit the job to label a blank tape. The user is allowed to edit this dataset for the desired information. The only parameter that the user needs to change is the volume name: VOL=NNNNNN. An example copy of the LABEL JCL is included in the appendix (APP5 - 2) following this section.

After the dataset has been edited and the user wishes to submit the job, go to COMMAND ===> at the top of the screen and type SUBMIT. Please refer to Sections 3.1.2.2 and 3.1.2.3 to verify successful job completion and to view diagnostic output.

Datasets Necessary to Run a GETSRC Tape

The following datasets are necessary to run a GETSRC tape.

JCL:	'XRMDD.LIB.CNTL(REQSRC)'	(ascii file)
GETSRC Source Code:	XR0125 F:8	(tape file)
Load Module:	'XRHKR.GETSRC.LOAD(GETSRC)'	(binary file)
X-Ray Catalog:	'XRHKR.XRAY.CAT8402'	(binary file)

Enter the dataset information into the ISPF Library as follows:

```
Project ===> XRMDD
Library ===> LIB
Type    ===> CNTL
Member  ===> REQSRC
```

This dataset (full name of XRMDD.LIB.CNTL(REQSRC)) contains the JCL required in order to submit the job to generate the GETSRC tape. The user is allowed to edit this dataset for the desired information.

All data fields between the lines (NOT inclusive) "*//GO.DATA5 DD **" and "*//EXEC NTSO*" are input data fields. The data elements should be altered, deleted or added as required. For example, if INEP = 0 (option NOT to create a North Ecliptic Pole tape), then DTPNEP (name of the output NEP tape) can be left blank. Please refer to the following discussion concerning the GETSRC Data Elements.

The following data elements must be verified each time a job is submitted.

```
DTAPE  - input MAX tape volume
NFILE  - input tape start file
ISTART - time interval flag; = 1 for search for the start
         of the time interval
IDAY1  - start day
ITIM1  - start time in milliseconds
IDAY2  - end day
ITIM2  - end time in milliseconds
```

DNAMSR - up to four source names
DTAPSR - output tape names for each source
RTASR - right ascension for each source
ADCSR - declination for each source
CONANG - cone angle for each source (if different than 0)
ISOURC - number of sources in this run
ICLNFG - clean flag: 1=clean data only; 0=all data
NOMAXT - number of input MAX tapes for this run

An example copy of the GETSRC dataset is included in the appendix (APP5 - 3).

To attain a copy of the Tape List (a listing of the IBM data tape names and corresponding days of data), contact Michele De La Pena at 286-2316 or Hwa-Ja Rhee at 286-3695.

After the dataset has been edited and the user wishes to submit the job, go to COMMAND===> at the top of the screen and type SUBMIT. A message will appear on the screen, indicating that the job has been submitted. For example,

JOB XRMDDGET(JOB03555) SUBMITTED
***

Refer to Section 3.1.2.2 in order to verify that the job has successfully been submitted and to Section 3.1.2.3 to view the output from the job run. When the job has successfully completed, go to the tape library in Building 1, Room 6, and pick up the output tape. The output tape is density 3 (1600 bpi) and can be read by various HEAO A-2 data analysis programs on the MicroVAX. Refer to Section 3.1.1 for logoff instructions for the IBM MVS Operating System.

GETSRC Data Elements to be submitted by the scientists

The following data elements are to be submitted by the scientists, using a GETSRC Request Form. This form may be obtained by contacting Michele De La Pena at 286-2316.

Required Entries on the GETSRC Request Form

Variable	Type	Default	Description
Start Day (IDAY1)	I*4	0	Start day of interval (for time selection)
End Day (IDAY2)	I*4	0	Stop day of interval (for selected MAX data by time)

APP5 - 1 continued

Name of Source (DNAMSR)	R*8		The source names (up to four source names, eight characters each) in the following format: DNAMSR='--------','--------', '--------','--------'
RA (RTASR)	R*4	4*0.0	Right ascension coordinates of the sources (maximum of four sources) (degrees, Epoch 1950) in the following format: 275.426600,0.0,0.0,0.0
DEC (ADCSR)	R*4	4*0.0	Declination coordinates of the sources (degrees, Epoch 1950) in the following format: 60.0,0.0,0.0,0.0
Clean Data Flag (ICLNFG)	I*4	1	=0, use all data on the input MAX tape =1, use only clean data

Optional Entries on the GETSRC Request Form

Variable	Type	Default	Description
Cone Angle (CONANG)	R*4	4*0.0	Half angles of solid angle cones which are generated about the source locations (degrees)
North Ecliptic Pole Flag (INEP)	I*4	1	North Ecliptic Pole (NEP) flag: =0, do not create a NEP tape =1, create a NEP tape
South Ecliptic Pole Flag (ISEP)	I*4	1	South Ecliptic Pole (SEP) flag: =0, do not create a SEP tape =1, create a SEP tape
Start Time (ITIM1)	I*4	0	Start time (in milliseconds of day)
Stop Time (ITIM2)	I*4	0	Stop time (in milliseconds of day)

APP5 - 1 continued

Galactic Equator (IGEQAT)	I*4	1	Galactic Equator (GE) flag: =0, do not create a GE tape =1, create a GE tape
X-Ray Source (ISOURC)	I*4	0	X-ray source flag: =0, do not create a source tape =n, create n source tapes (n=1, 2, 3, or 4)

GETSRC Data Elements to be submitted by the programmers

The following data elements are to be submitted by the programmers when entering GETSRC JCL statements.

The variables for NAMELIST GETSRC1 are:

Variable	Type	Default	Description
DTAPE	R*8	'XR0000'	MAX input tape volume serial number of the first input tape (alphanumeric, six characters)
DTPNEP	R*8		Volume serial number of the North Ecliptic Pole output tape (alphanumeric, six characters) DTPNEP='XR0010'
DTPSEP	R*8		The volume serial number of the South Ecliptic Pole output tape (alphanumeric)
DTPGAL	R*8		Volume serial number of the Galactic Plane output tape (alphanumeric)
DTPSR	R*8		Volume serial numbers of the source output tapes (alphanumeric)
NFILE	I*4		Starting file number of the MAX tape (DTAPE)
ISTART	I*4	3	Time interval flag: =1, search for start of the interval =2, search for end of the interval =3, start at the beginning of the file

APP5 - 1 continued

NFILOT	I*4	1	Starting file on the output tape
NOMAXT	I*4	1	Number of MAX input tape volumes

The variables for NAMELIST GETSRC2 are:

Variable	Type	Default	Description
GETSRC2			Include this name list if more than one input tape volume serial number is to be processed
DTAPE	R*8		The MAX input tape volume serial number for the corresponding MAX tape (e.g., the first occurrence of GETSR2 corresponds to the second MAX tape) (alphanumeric, six characters)
NFILE	I*4	1	Must be included when using GETSRC2 variable. Denotes the starting file number of the corresponding MAX tape (DTAPE)

Note: In the Type column, I = integer and R = real number.

For additional information, please refer to the following manual: *High Energy Astronomy Observatory Satellite-A (HEAO A2) GETSRC Program Description and Operator's Guide*, #CSC/TM-79/6030, July, 1979.

GETSRC REQUEST FORM

Date ______________

Name ________________________ Room __________

The user may request up to four sources for one time period. For different time periods, please use separate GETSRC Request Forms.

	1	2	3	4
SOURCE NAME	________	________	________	________
POSITION (1950 Coordinates)				
R.A.	________	________	________	________
DEC	________	________	________	________
CONE ANGLE (Degrees -- Default 0.0)	________	________	________	________
START DAY	________			
END DAY	________			

ALL DATA or CLEAN DATA ONLY (A or C)

____

(Staff Use Only)

Date Completed ______________

Problems ____

LABEL JCL

```
1. //XRMDDLBL JOB (SB018,350,1),LABEL,MSGCLASS=X,TIME=(1,0),
2. //  NOTIFY=XRMDD
3. //*JOBPARM QUEUE=FETCH
4. //  EXEC LABEL,VOL=MDD01,DEN=3,LABEL=NL,TUNIT=1600
5. // EXEC NTSO
6. //
7. //
```

****

Bold Face Text denotes information that should be changed by the specific user.

Line 1: XRMDD = user's logon
SB018 = user's account
350 = output location
Line 2: XRMDD = user's logon
Line 4: MDD01 = output tape name. Maximum of 8 alphanumeric characters.

GETSRC JCL

```
//XRMDDREQ JOB (SB018,350,20),REQSRC,MSGCLASS=X,TIME=(3,30)
/* THIS JCL IS FOR A GETSRC RUN
//GETSRC PROC
//GO EXEC PGM=GETSRC,REGION=300K
//STEPLIB DD DISP=SHR,DSN=XRHKR.GETSRC.LOAD
//GO.FT05F001 DD DDNAME=DATA5
//GO.FT06F001 DD SYSOUT=X,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//GO.SYSPRINT DD SYSOUT=X,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//GO.SYSUDUMP DD SYSOUT=A,SPACE=(CYL,(1,1)),
//  DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//GO.FT10F001 DD UNIT=(6250,,DEFER),DISP=(OLD,KEEP),LABEL=(1,NL),
//   DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=4),
//   DSN=ZBHED.MAX.TAPE,VOL=(PRIVATE,RETAIN,SER=XR0111)
//* LOGICAL UNIT 11 IS RESERVED FOR XRAY CATLOG
//GO.FT11F001 DD DSN=XRHKR.XRAY.CAT8402,DISP=SHR
//* LOGICAL UNIT 20 IS RESERVED FOR NORTH ECLIPTIC POLE OPTION
//GO.FT20F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=NEPOPT
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&NEP,VOL=SER=NEPOPT
//* LOGICAL UNIT 21 IS RESERVED FOR SOUTH ECLIPTIC POLE OPTION
//GO.FT21F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//  DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=SEPOPT
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&SEP,VOL=SER=SEPOPT
//* LOGICAL UNIT 22 IS RESERVED FOR GALACTIC PLANE OPTION
//GO.FT22F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=GALOPT
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&GAL,VOL=SER=GALOPT
//* LOGICAL UNIT 23 IS RESERVED FOR THE 1ST X-RAY SOURCE
//GO.FT23F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=FIRSRC
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&SRC1,VOL=SER=FIRSRC
//* LOGICAL UNIT 24 IS RESERVED FOR THE 2ND X-RAY SOURCE SELECTED
//GO.FT24F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=SECSRC
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&SRC2,VOL=SER=SECSRC
//* LOGICAL UNIT 25 IS RESERVED FOR THE 3RD SOURCE SELECTED
//GO.FT25F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=THRSRC
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//* DSN=&SRC3,VOL=SER=THRSRC
//*  LOGICAL UNIT 26 IS RESERVED FOR THE 4TH SOURCE SELECTED
//GO.FT26F001 DD UNIT=(1600,,DEFER),DISP=(NEW,KEEP),LABEL=(1,NL),
//   DCB=*.GO.FT10F001,DSN=NULLFILE,VOL=SER=FORSRC
//* DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
```

APP5 - 3 continued

```
37B.//* DSN=&SRC4,VOL=SER=FORSRC
38. //PEND PEND
39. //STEP1 EXEC GETSRC
40. //GO.DATA5 DD *
41.  &GETSR1
42.  DTAPE='XR0391',DTPNEP='XR0000',DTPSEP='XR0000',DTPGAL='XR0000',
43.  DTPSR='MDD01',
44.  DNAMSR='H0449-55',
45.  RTASR=73.131,0.0,0.0,0.0,ADCSR=-55.941,0.0,0.0,0.0,
46.  CONANG=0.0,0.0,0.0,0.0,ICLNFG=1,
47.  INEP=0,ISEP=0,IGEQAT=0,ISOURC=1,
48.  NFILE=1,ISTART=1,IDAY1=388,ITIM1=00000000,NFILOT=1,
49.  IDAY2=390,ITIM2=99999999,NOMAXT=1,
50.  &END
51. //* &GETSR2 DTAPE='XR0000',NFILE=1, &END
52. //
53. //
```

****

Bold Face Text denotes information that should be changed by the specific user.

```
Line 1:  XRMOD = user's logon
         SB018 = user's account
         350   = output location
Line 18: This is the default JCL; no output tape will be generated.
         If a tape is to be generated, use lines 18A and 18B.  Any
         temporary output name must be supplied (i.e., &NEP).
Line 21: This is the default JCL; no output tape will be generated.
         If a tape is to be generated, use lines 21A and 21B.  Any
         temporary output name must be supplied (i.e., &SEP).
Line 24: This is the default JCL; no output tape will be generated.
         If a tape is to be generated, use lines 24A and 24B.  Any
         temporary output name must be supplied (i.e., &GAL).
Line 27: This is the default JCL; no output tape will be generated.
         If a tape is to be generated, use lines 27A and 27B.  Any
         temporary output name must be supplied (i.e., &SRC1).
Line 31: This is the default JCL; no output tape will be generated.
         If a second tape is to be generated, use lines 31A and 31B.
         Any temporary output name must be supplied (i.e., &SRC2).
Line 34: This is the default JCL; no output tape will be generated.
         If a third tape is to be generated, use lines 34A and 34B.  Any
         temporary output name must be supplied (i.e., &SRC3).
Line 37: This is the default JCL; no output tape will be generated.
         If a second tape is to be generated, use lines 37A and 37B.
         Any temporary output name must be supplied (i.e., &SRC4).
Line 42: DTAPE  = input MAX tape volume
         DTPNEP = volume serial number of the North Ecliptic Pole
                  output tape
```

DTPSEP = volume serial number of the South Ecliptic Pole ouput tape
DTPGAL = volume serial number of the Galactic Plane Pole output tape.
Line 43: DTPSR = volume serial numbers of the source output tapes Maximum of four output tapes.
Line 44: DNAMSR = names of sources. Up to four source names may be included.
Line 45: RTASR = right ascension for each source (1950 coordinates)
ADCSR = declination for each source (1950 coordinates)
Line 46: CONANG = cone angles for each source
ICLNFG = clean flag
Line 47: INEP = North Ecliptic Pole flag
ISEP = South Ecliptic Pole flag
IGEQAT = Galactic Equator flag
ISOURC = X-ray source flag
Line 48: NFILE = input tape start file
ISTART = time interval flag
IDAY1 = start day
ITIM1 = start time in milliseconds
NFILOT = starting file on the output tape
Line 49: IDAY2 = end day
ITIM2 = end time in milliseconds
NOMAXT = number of input MAX tapes for this run
Line 51: If more than one input tape is to be processed (NOMAXT > 1), this line must be included. Moreover, this line must be included for EACH subsequent input tape volume.

6.0 SOURCE FLUXES

In order for the user to obtain a feeling for the magnitude of the flux of a given source, the user may proceed in one of three ways (as described in Sections 6.1, 6.2, and 6.3). The *HEAO A2 Catalogue of Pre-HEAO Sources* (the "Blue Book") provides rough estimates of average fluxes for sources, and will give the user some idea of the magnitude of the flux. Moreover, since 25 degrees of scan angle are displayed, centered on the source coordinates, other sources which may be in the field of view are revealed. The published results in Section 6.2 are for specific sources and are the most accurate fluxes available. However, it is possible that these papers do not provide the user with any information pertaining to the particular object of interest. Finally, the user may utilize the data analysis software (DSDISK program) to determine the flux of any given source.

6.1 BLUE BOOK

The "Blue Book" or the *HEAO A2 Catalogue of Pre-HEAO Sources*, by Dr. F.E. Marshall, et al., consists of plots of the counting rates obtained with the hard X-Ray detectors of the HEAO A2 experiment. Each plot illustrates the count rates within a 25 degree scan angle around the source. Scans over the source are summed for the days when the source was observed.

6.2 PUBLISHED RESULTS

New Hard X-Ray Sources Observed with HEAO A-2, by F.E. Marshall, E.A. Boldt, S.S. Holt, R.F. Mushotzky, S.H. Pravdo, R.E. Rothschild, and P.J. Serlemitsos, Ap.J. Supp. 40: 657, 1979.

A Complete X-Ray Sample of the High Latitude Sky from HEAO 1 A-2, by G. Piccinotti, R.F. Mushotzky, E.A. Boldt, S.S. Holt, F.E. Marshall, and P.J. Serlemitsos, Ap.J. 253, 485, 1982.

The Absence of Rapid X-Ray Variability in Active Galaxies, by Allyn F. Tennant and R.F. Mushotzky, Ap.J 264, 92, 1983.

The HEAO A2 Survey of Abell Clusters and the X-Ray Luminosity Function, by J.D. McKee, R.F. Mushotzky, E.A. Boldt, S.S. Holt, F.E. Marshall, S.H. Pravdo, and P.J. Serlemitsos, Ap.J. 242, 857, 1980.

6.3 FLUX DETERMINATION

6.3.1 The DSDISK Program

The DSDISK program accumulates the scanning data available in the vicinity of a given object's position, and indicates the times when the source was in view. Time is divided into twelve-hour allocations. Data are accumulated for 25 degrees of scan angle during times when the source is in the experiment's field of view (fov). Normally, data are taken from the 1.5 x 3 degree fov of MED and HED3, but data are available for the 3 x 3 degree fov.

Two ascii output files are created by the DSDISK program: DSDISK.OUT and DSDISK.TMP. The "DSDISK.OUT" file is in line-printer format and provides documentation on the execution of the program. The "DSDISK.TMP" file has the format of what is termed a "scan" file and contains information that can be analyzed using the programs SCANN, AUTSCN, or PLTCAT.

If you have many sources to examine and/or the coordinates need to be converted to the proper input format, see sections 6.3.1.3 and 6.3.1.2.

6.3.1.1 Discussion of the DSDISK Options

In order to run the DSDISK program, input information will be asked of the user. It is possible for the user to obtain useful output by using all of the default values in the program and only having to input the source name and coordinates. The following paragraphs discuss the various program prompts.

ENTER 1 TO USER 3 DEG FOV DATA BASE
DEFAULT FOR 1.5 DEG FOV DATA BASE
An input of "0" or a <CR> will allow access to the 1.5 x 3.0 degree field of view of the MED and HED3 detectors; an input of "1" will allow access to the 3.0 x 3.0 degree field of view of the MED and HED3 detectors.

ENTER BETA (DEFAULTS TO 0.6)
The BETA parameter is used to determine the number of days of data to be utilized. For a source in the ecliptic plane, the program will accumulate data for roughly BETA*5.7 days centered at the day of the peak response of the source. The default BETA of 0.6 provides the optimum amount of data for weak sources.

ENTER VWDAY. DEFAULTS TO 235
The VWDAY parameter determines which view of the source is desired. All sources were viewed twice (once every six months), and some sources were viewed for a third time before the experiment terminated. The variables VWDAY,VIEW_OFFSET and IVIEW are specifically used in this determination. The program will choose the (IVIEW + VIEW_OFFSET) time after the first view beyond VWDAY that the experiment scanned directly over the source. The data base contains data from day 232.1 through 737.1 although the useful data is considered to be in the range of day 235 - 721.

ENTER 1 TO WEIGHT BY DAILY EFFICIENCY
An input of "0" will allow the program to weight all of the data equally. An input of "1" will cause the program to weight the data by the effective response of the experiment to the source. In general for strong sources, the data should be weighted equally (0); for weak sources (<5 UFU -- UHURU Flux Unit), the data should be weighted by the effective response (1).

ENTER VIEW_OFFSET (I5)
An input of "0" refers to the first scan (first 6 month time frame, day 232.1 - day 454.9) of the experiment; an input of "1" refers to the second scan (second 6 month time frame, day 400.1 - day 614.6) of the experiment.

ENTER 1 TO INPUT RA AND DEC FROM DISK
The RA (right ascension) and DEC (declination) are the coordinates of the target source. An input of "0" to this prompt will require the user to input the coordinates (in a later prompt) directly from the keyboard. An input of "1" implies that the user has created an input file which contains the necessary input information. Please refer to Section 6.3.1.3 to create an input disk file.

If the previous prompt were answered with a "1" indicating a disk file containing input coordinates, the next prompt will be issued.

ENTER DISK NAME
The user should input the name of the disk file containing the necessary source and coordinate information.

SET UP WEIGHTS FOR DISCOVERY SCALARS.
ENTER 0 TO USE DEFAULT VALUES FOR TOTAL RATE.
ENTER 1 TO USE DEFAULT VALUES FOR HARD RATE.
ENTER 2 TO USE DEFAULT VALUES FOR SOFT RATE.
ENTER 3 TO USE DEFAULT VALUES FOR R15 RATE.
ENTER 4 TO USE DEFAULT VALUES FOR WTD R15 RATE.
ENTER 5 TO USE DEFAULT VALUES FOR MED M1 RATE.
ANY OTHER VALUE TO ENTER NEW VALUES FROM KEYBOARD.
It is strongly advised that the user choose the pre-defined values for the desired option.

Discovery Scalars are the eight rates accumulated in various combinations of spatial and spectral windows. They are useful for analysis of temporal variability since they are available on a finer timescale than the histograms, but still contain some spectral information.

The pre-defined values for each of the above rates are listed in the appendix.

If a value other than 0-5 were entered for the preceeding prompt, the following prompt will be issued.

THE DISCOVERY SCALARS CHANGED DURING THE HEAO 1 MISSION.
EACH SETTING FOR THE DISCOVERY SCALARS IS CALLED A "MODE".
THERE WERE 6 MODES FOR SCANNING. DIFFERENT COLORS ARE
AVAILABLE TO THIS PROGRAM DEPENDING ON THE MODE.
THE AVAILABLE COLORS ARE:
MODE 1: HD3 M1,M2,-,- MED M1,-,-,-
MODE 2: HD3 M1,M2,-,- MED M1,M2,-,-
MODE 3: HD3 M1,M2,-,- MED 1ACD,1B,2A,2B

MODE 4: HD3 1AD,1B,1C,M2 MED 1ACD,1B,2A,2B
MODE 5: HD3 1A,1B,1CD,M2 MED 1ACD,1B,2A,2B
MODE 6: HD3 1A,1B,1CD,M2 MED 1A,1B,1CD,M2
YOU CAN WEIGHT THE AVAILABLE COLORS AS DESIRED.
YOU SHOULD CHOOSE THE WEIGHTS SO THAT EACH MODE PRODUCES APPROXIMATELY THE SAME SUMMED RATE.
ENTER MODE (1-6), 8 WTS. (I3,8F8.0)
MODE=0 OR > 6 TO QUIT

Please see the appendix (APP6 - 1) for the suggested values for the preceding weights.

ENTER 1 TO CHANGE ANTI-COEFF.
This parameter is used to correct the rates by an amount proportional to the anti-coincidence rate; it is used to "flatten out" the background data. An input of "0" will use the default values. An input of "1" will allow the user to change the anti-coincidence coefficient; the user is encouraged not to alter this parameter.

The pre-defined values for the anti-coefficients are listed in the appendix.

If the user entered "1" for the last prompt concerning the anti-coefficient rate, the following will be displayed.

THE ANTI-COEFF IS DEFINED AS THE EXPECTED CHANGE
IN THE COUNT RATE/SEC FOR A CHANGE IN THE ANTICO RATE
OF 1000/MAJOR FRAME. IT MAY BE DIFFERENT FOR DIFFERENT MODES.
ENTER MODE (1-6), ANTI-CO (I3,F8.0)
MODE=0 OR > 6 TO QUIT

If the user did not input the name of a disk file containing the source name and coordinates in a previous prompt, the user will now be prompted for this information.

ENTER TITLE(A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)

TITLE is a nine character alphanumeric label for the object. This label may include blank spaces in the instance of a short object name; however, a comma MUST NOT be used to separate the TITLE parameter from the RA parameter. Two examples of input are:
MYOBJECT173.21,10.2
MYOBJ1   73.21,10.2

RA and DEC must be entered as decimal degrees (1950 epoch). If RA is a negative value, the program will assume that the inputs (RA and DEC) represent times and will accumulate data from RA to DEC centered at ANGL. If the coordinates are in hours, minutes and seconds or are galactic, please see Section 6.3.1.3 to set up a disk file.

ANGL is in units of degrees and is only used if RA is a negative quantity denoting time in days. It is the scan angle for a particular source. The default for this parameter is "0".

IVIEW indicates the first time that the source has been observed after the view day (VWDAY). The default for this parameter is "0"; if a value is input, the value will be added to the number in the prompt *ENTER VIEW_OFFSET (I5)*.

IPLT is an option for a plot of the scan on the terminal screen. An input of "0" (default) indicates no plot; an input of "1" indicates that a plot is desired.

IAUTO is an option to produce six scan records of equal time intervals for each source. An input of "0" (default) produces only one scan record; an input of "1" produces the six scan records.

IWRT is a toggle to turn off the output data. An input of "0" (default) will produce an output disk file; an input of "1" will NOT produce an output disk file.

At this time, the program will accumulate the required data from the data base. The time span will be displayed on the terminal screen for the requested target.

If the IPLT option were chosen (1) then the user will be prompted for the plot.

PLOT?

The user may now enter "0" for no plot, or "1" for display of a a plot on the terminal screen.

If the user answered "1" to the above question, the following prompt will be displayed by the plot package.

```
POSSIBLE GRAPHICS DEVICES:
P -- PRINTRONIX      V -- VERSATEC      L -- LIACOM
T -- TEKTRONIX       5 -- VT152         Z -- ZETA
A -- ARGS            G -- GRINNELL      N -- NULL
SELECT GRAPHICS DEVICE FOR CURRENT PLOT: T
WHICH TEKTRONIX TERMINAL IS FREE? <CR>
```

The plot will now be displayed for the user on the terminal screen.

ENTER TITLE (A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)
This prompt will be redisplayed after the requested information. The user may enter a new source and coordinates using the same input constraints, or a ^Z to end this set of inputs.

ENTER 1 TO RESTART PROGRAM
This is an option to input new data from the choice of database prompt. An input of "0" will terminate the program operation; an input of "1" will restart the program.

The following section gives two example runs of the DSDISK program. The first example is a run using the default values where the default values are typed explicitly; the second example is a run in which the user wishes to use values other than the defaults.

6.3.1.2 Two Example Runs of the DSDISK Program

<u>Example 1 -- Default Run</u>

```
$ RUN [XRAY]DSDISK

THIS PROGRAM READS DSDISK DATA BASE AND CREATES SCAN FILES
CENTERED AT CHOSEN TARGETS USING SELECTED DISCOVERY SCALER
RATES FROM THE MED AND MED3 DETECTORS.

"LINE PRINTER" OUTPUT   IN DSDISK.OUT.
OUTPUT DISK FILE IS "D   SK.TMP".

ENTER 1 TO USE 3 DEG FOV DATA BASE
DEFAULT FOR 1.5 DEG FOV DATA BASE.
0

ENTER BETA (DEFAULTS TO 0.6)
0.6

ENTER VWDAY.  DEFAULTS TO 235
235

ENTER 1 TO WEIGHT BY DAILY EFFICIENCY
0

ENTER VIEW-OFFSET (I5)
0

INPUT RA AND DEC FROM DISK
1

ENTER DISK NAME
INPUT.DAT

SET UP WEIGHTS FOR DISCOVERY SCALERS.
ENTER 0 TO USE DEFAULT VALUES FOR TOTAL RATE.
ENTER 1 TO USE DEFAULT VALUES FOR HARD RATE.
ENTER 2 TO USE DEFAULT VALUES FOR SOFT RATE.
ENTER 3 TO USE DEFAULT VALUES FOR R15 RATE.
ENTER 4 TO USE DEFAULT VALUES  FOR WTD R15 RATE.
ENTER 5 TO USE DEFAULT VALUES FOR MED M1 RATE.
ANY OTHER VALUE TO ENTER NEW VALUES FROM KEYBOARD.
0

ENTER 1 TO CHANGE ANTI-COEFF.
0

ENTER TITLE(A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)
```

If there were a data file containing target positions, the time span (in days and decimals of a day) would be displayed for the requested observations.

```
ENTER TITLE(A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)
ENTER 1 TO RESTART PROGRAM
0

FORTRAN STOP
$
```

The line-printer output is found in the DSDISK.OUT file; the output file DSDISK.TMP will be used as input for other data processing programs. The output from this DSDISK run, Example 1, is included in the appendix (APP6 - 2) following this chapter.

<u>Example 2</u>

```
$ RUN [XRAY]DSDISK

THIS PROGRAM READS DSDISK DATA BASE AND CREATES SCAN FILES
CENTERED AT CHOSEN TARGETS USING SELECTED DISCOVERY SCALER
RATES THE MED AND HED3 DETECTORS.

"LINE PRINTER" OUTPUT IS IN DSDISK.OUT.
OUTPUT DISK FILE IS "DSDISK.TMP".

ENTER 1 TO USE 3 DEG FOV DATA BASE
DEFAULT FOR 1.5 DEG FOV DATA BASE.
1

ENTER BETA (DEFAULTS TO 0.6)
0.8

ENTER VWDAY.  DEFAULTS TO 235
260

ENTER 1 TO WEIGHT BY DAILY EFFICIENCY
1

ENTER VIEW-OFFSET (I5)
0

INPUT RA AND DEC FROM DISK
0

SET UP WEIGHTS FOR DISCOVERY SCALERS.
ENTER 0 TO USE DEFAULT VALUES FOR TOTAL RATE.
ENTER 1 TO USE DEFAULT VALUES FOR HARD RATE.
ENTER 2 TO USE DEFAULT VALUES FOR SOFT RATE.
ENTER 3 TO USE DEFAULT VALUES FOR R15 RATE.
ENTER 4 TO USE DEFAULT VALUES  FOR WTD R15 RATE.
ENTER 5 TO USE DEFAULT VALUES FOR MED M1 RATE.
ANY OTHER VALUE TO ENTER NEW VALUES FROM KEYBOARD.
```

```
THE DISCOVERY SCALARS CHANGED DURING THE HEAO 1 MISSION.
EACH SETTING FOR THE DISCOVERY SCALARS IS CALLED A "MODE".
THERE WERE 6 MODES FOR SCANNING.  DIFFERENT COLORS ARE
AVAILABLE TO THIS PROGRAM DEPENDING ON THE MODE.
THE AVAILABLE COLORS ARE:
MODE 1:  HD3 M1,M2,-,-      MED M1,-,-,-           233.1 -
MODE 2:  HD3 M1,M2,-,-      MED M1,M2,-,-          245.7 -
MODE 3:  HD3 M1,M2,-,-      MED 1ACD,1B,2A,2B      248.2 -
MODE 4:  HD3 1AD,1B,1C,M2   MED 1ACD,1B,2A,2B      304.9 -
MODE 5:  HD3 1A,1B,1CD,M2   MED 1ACD,1B,2A,2B      321.8 -
MODE 6:  HD3 1A,1B,1CD,M2   MED 1A,1B,1CD,M2
YOU CAN WEIGHT THE AVAILABLE COLORS AS DESIRED.
YOU SHOULD CHOOSE THE WEIGHTS SO THAT EACH MODE PRODUCES
APPROXIMATELY THE SAME SUMMED RATE.
ENTER MODE (1-6), 8 WTS. (I3,8F8.0)
MODE=0 OR > 6 TO QUIT
5,0.9,0.9,0.3,0.2,0.7,0.7,0.74,0.74
0

ENTER 1 TO CHANGE ANTI-COEFF.
1

THE ANTI-COEFF IS DEFINED AS THE EXPECTED CHANGE
IN THE COUNT RATE/SEC FOR A CHANGE IN THE ANTICO RATE
OF 1000/MAJOR FRAME.  IT MAY BE DIFFERENT FOR DIFFERENT MODES.
ENTER MODE (1-6), ANTI-CO (I3,F8.0)
MODE=0 OR > 6 TO QUIT
5,0.201
0

ENTER TITLE (A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)
arcturus 213.75,19.25,0.0,1,0,1,0
```

The information requested is now printed to the screen.

```
ENTER TITLE (A9),RA,DEC,ANGL,IVIEW,IPLT,IAUTO,IWRT (^Z TO QUIT)
^Z

ENTER 1 TO RESTART PROGRAM
0

FORTRAN STOP
$
```

The line-printer output is found in the DSDISK.OUT file; the output file DSDISK.TMP will be used as input for other data processing programs. The output from this DSDISK run, Example 2, is included in the appendix (APP6 - 3) following this chapter.

6.3.1.3 Creating a disk file containing the RA and DEC Coordinates

The user can create a file containing the object name and the corresponding RA (right ascension) and DEC (declination) coordinates (e.g., NAME.POS). Please see section 3.2.3 in order to edit or create a file. Enter the data in the NAME.POS file as follows: OBJECT_NAME, RA, DEC, ANGLE, IVIEW, IPLT, IAUTO, IWRT.

```
OBJ45678 01.0354,-45.1345,0.0,0,0,0,0
```

The first nine characters are the source name and are alphanumeric; blank spaces may be included. The next two parameters give the RA and DEC of the object. The coordinates should be the 1950 source coordinates and can be celestial (RA and DEC) or galactic (L and B). The style of the coordinates can be represented as decimal degrees or as HH.MMSS and DD.MMSS. These two parameters may also be entered as time in days where RA is the beginning day in the form -DDD and DEC is the ending day in the form DDD. The negative sign in front of the RA coordinate indicates that the RA and DEC inputs are not actually coordinates, but rather, they are times. Data will be accumulated from the absolute value of the RA through the DEC value.

Enter as many object names and coordinates as desired, for example:

```
MYOBJECT11.0354,-45.1345
MYOBJECT2-381.0,388.0,149.0,1,0,1,0
MYOBJECT323.3201,-01.0459
MYOBJ    1.0354,-45.1345
[EOB]
```

Please note that the first nine characters of input are used as the object name. This label may include blank spaces in the instance of a short object name; however, a comma MUST NOT be used to separate the TITLE parameter from the RA parameter. The remaining input parameters should be separated by commas. Some examples of input which will NOT work are:

```
MYOBJECT1,1.0354,-45.1345
MYOBJ,1.0354,-45.1345
MYOBJ1.0354,-45.1345
MYOBJECT11.0354-45.1345
```

After you have entered all of the desired information, press the "Control" and "Z" keys simultaneously.

```
* EXIT
```

A message will be displayed indicating the disk drive, directory name, position file name, and number of lines within the file. For example:

$DISK1:[DELAPENA]NAME.POS:1 5 lines.

Unless you entered positions as decimal degrees of RA and DEC or as time (negative RA parameter in days), you MUST run the program SORTRA.

6.3.2 The SORTRA Program

The SORTRA program transforms coordinates from their natural units (RA in hours, minutes, and seconds and DEC in degrees, arc minutes, and arc seconds) into degrees and decimals of a degree. SORTRA converts data into a form which is suitable to be read by the DSDISK program. The input file to the SORTRA program must be in the format as described in section 6.3.1.3.

```
$ RUN [XRAY]SORTRA

THIS PROGRAM READS A DATA FILE AND CONVERTS
IT FOR USE AS INPUT POSITIONS FOR THE DSDISK PROGRAM.
INPUT POSITIONS CAN BE IN RA AND DEC IN DECIMAL DEGREES
OR HOURS-MINUTES-SECONDS OR IN GALACTIC COORDINATES.
OUTPUT FILE IS CALLED "SORT.TMP"
LINE PRINTER OUTPUT IS IN "SORTRA.OUT"

ENTER INPUT DISK FILE NAME
indec.dat

AN OLD VERSION OF DSDISK ALLOWED ONLY 8 CHARACTERS
FOR THE SOURCE NAME INSTEAD OF NOW STANDARD 9
TYPE 1 IF YOU ARE USING A FILE WITH THE OLD FORMAT
0

TYPE 1 FOR INPUT IN HOURS-MINUTES-SECONDS
1
```

If "1" were input for the previous prompt, the following message will be displayed:

```
FORMAT IS HH.MMSS AND DD.MMSS
```

```
TYPE 1 FOR INPUT IN GALACTIC L & B
0

ENTER 1 TO SORT OUTPUT FILE BY OBSERVATION TIME
1
```

If you enter "1", the output file will be sorted by the observation time for the source.

```
FORTRAN STOP
$
```

The results of the SORTRA program are automatically stored in a disk file named SORT.TMP which can be used as the input file in the DSDISK program.

Sample output from this program (SORT.TMP and SORTRA.OUT) run are located in the appendix at the end of this chapter (APP6 - 4).

6.3.3 Processing the Data

To process the data stored in a "scan-style" files (output from the DSDISK program), the following programs can be used: AUTSCN, SCAN and PLTCAT.

6.3.3.1 The AUTSCN Program

AUTSCN reads data and computes fluxes and errors by calculating a least squares fit.

6.3.3.1.1 Discussion of the AUTSCN Options

The prompts for the input information for this program have been written to be self-explanatory. In most cases, no further explanation is required.

THE PROGRAM RUNS IN 3 DIFFERENT MODES:
1: MANUAL MODE IN WHICH YOU DECIDE WHERE SOURCES ARE
2: AUTOMATIC MODE IN WHICH PROGRAM RUNS AUTOMATICALLY
3: FIXED MODE IN WHICH THERE IS A FIXED LIST OF SOURCES
MOST USERS SHOULD CHOOSE MODE 2
ENTER MODE (A NUMBER FROM 1 TO 3)

The mode "1" option is actually better accomplished by another program, SCAN. Please see Section 6.3.3.2 for the discussion of the SCAN program.

If option "2" were chosen for the mode, the following question appears:

THERE ARE 3 DIFFERENT STYLES FOR THIS MODE
1: PROGRAM PUTS SOURCES WHERE IT DEEMS APPROPRIATE
2: PROGRAM PUTS A SOURCE WITH FIXED POSITION AT THE TARGET SCAN ANGLE AND ADDS OTHER SOURCES AS APPROPRIATE
3: SAME AS STYLE 2, BUT TARGET SOURCE POSITION IS ALLOWED TO VARY
ENTER STYLE (A NUMBER FROM 1 TO 3)

If the user had chosen mode "3", the following question appears:

THERE ARE 2 DIFFERENT STYLES FOR THIS MODE
1: THERE IS ONLY A FIXED LIST OF SOURCES
2: THE PROGRAM ADDS ADDITIONAL SOURCES AS APPROPRIATE
ENTER STYLE (A NUMBER FROM 1 TO 2)

YOU CAN SELECT WHICH GROUPS OF SCANS IN YOUR DATA FILE TO ANALYZE
ENTER THE 1ST AND LAST SCANS (FORMAT 2I5)
JUST HIT RETURN TO ANALYZE ENTIRE FILE

THE PROGRAM MAY HAVE DIFFICULTIES PRODUCING AN ACCEPTABLE FIT IF THERE ARE BRIGHT SOURCES (>25 COUNTS/SEC) IN THE DATA.
THE PROGRAM WILL ELIMINATE REGIONS TOWARD THE ENDS OF THE SCANS CONTAINING SOURCES BRIGHTER THAN "SMAX".
ENTER SMAX (FORMAT F10.0). DEFAULT VALUE IS 75.

THE PROGRAM PRODUCES AN ESTIMATE OF THE BRIGHTNESS OF THE TARGET SOURCE BY FILTERING THE DATA NEAR THE TARGET SOURCE POSITION.
DATA ARE USED IF THE COLLIMATOR RESPONSE TO THE SOURCE IS GREATER THAN "WMIN". ENTER WMIN (FORMAT F10.0). DEFAULT VALUE IS 0.4.

If option "2" were chosen for the mode, the following question appears:

THE PROGRAM INSERTS NEW SOURCES IN THE FIT MODEL
IF THEIR SIGNIFICANCE IS > THAN "SRCSIG"
ENTER SRCSIG (FORMAT F10.0). DEFAULT VALUE IS 3.0

If the user had chosen mode "3", the following question would appear:

THE PROGRAM INSERTS NEW SOURCES IN THE FIT MODEL
IF THEIR SIGNIFICANCE IS > THAN "SRCSIG"
ENTER SRCSIG (FORMAT F10.0). DEFAULT VALUE IS 3.0

ENTER 1 TO USE SIMPLE TRIANGULAR COLLIMATOR RESPONSE
DEFAULT IS SMEARED TRIANGLE.

If the user had chosen mode "3", the following questions would appear:

ENTER POS. DISK FILE

The position disk file should contain the RA and DEC coordinates (decimal degrees) of each object in the format 2F10.0; one set of coordinates per line. This file may have a maximum of ten input sets of coordinates.

ENTER 1 TO RESTART

The user may enter "0" or "1". An input of "0" will resume with the next prompt concerning the collimator size. An input of "1" will repeat the prompt *ENTER POS. DISK FILE* and allow the user to enter a different position file to be used.

TYPE 1 TO ENTER NON-STANDARD COLLIMATOR SIZE

If the user input "1" to enter a non-standard collimator size, the following prompt would appear:

ENTER COLLIMATOR SIZE IN DEGREES (FORMAT F10.0)

YOUR SCAN FILE CONTAINS THE SCAN ANGLE OF THE TARGET SOURCE.
AN OFFSET ANGLE, WHICH WILL BE ADDED TO THAT SCAN ANGLE
CAN NOW BE ENTERED. THE OFFSET IS IN DEGREES (FORMAT F10.0)
DEFAULT VALUE IS 0.

ENTER DISC FILE NAME (FORMAT 60A1)
Output from the DSDISK program is entered here (i.e., dsdisk.tmp).

If mode "2" were chosen, the following would be displayed on the terminal screen:

IREC, TITLE = 1   XXXXXXXXX

If mode "3" were chosen, the following would be displayed on the terminal screen:

IREC, TITLE = 1   XXXXXXXXX

```
1.    NNN.NN    -N    N.NNN    N.NNN    N.NNN    NNN.NNN
                                .
                                .
                                .
5.    NNN.NN    -N    N.NNN    N.NNN    N.NNN    NNN.NNN
```

If modes "2" or "3" were chosen, the AUTSCN.TMP and AUTSCN.OUT files would be written to the user's directory, and the program would exit.

FORTRAN STOP
$

If mode "1" were chosen, the following would be displayed on the terminal screen:

IREC, TITLE = 1   XXXXXXXXX

INPUT RA, DEC(1950), EXTENT, AND EXT TYPE FOR FIXED SOURCE 1

This prompt begins the portion of the AUTSCN program which is the same as the SCAN program. In fact, the program now proceeds with prompts as in the program SCAN. Please see the next section (6.3.3.2) for the discussion of the SCAN program information.

When the data have been processed, a FORTRAN STOP message will be displayed. The program records the results of the fits in a file called AUTSCN.TMP, which can be used in subsequent analysis programs (e.g., LSTAUT). A lineprinter recording of the data inputs (as well as additional information) has been written to a disk file, AUTSCN.OUT.

6.3.3.1.2 Example Run of the AUTSCN Program

PROGRAM AUTSCN READS FILES IN SCAN FORMAT,
AUTOMATICALLY SEARCHES FOR SOURCES,
AND DOES A LEAST SQUARES FIT.
RESULTS ARE WRITTEN TO DISK FILE "AUTSCN.TMP"
"LINE PRINTER" OUTPUT IS IN "AUTSCN.OUT"

THE PROGRAM RUNS IN 3 DIFFERENT MODES:
1: MANUAL MODE IN WHICH YOU DECIDE WHERE SOURCES ARE
2: AUTOMATIC MODE IN WHICH PROGRAM RUNS AUTOMATICALLY
3: FIXED MODE IN WHICH THERE IS A FIXED LIST OF SOURCES
MOST USERS SHOULD CHOOSE MODE 2
ENTER MODE (A NUMBER FROM 1 TO 3)

```
2

THERE ARE 3 DIFFERENT STYLES FOR THIS MODE
1: PROGRAM PUTS SOURCES WHERE IT DEEMS APPROPRIATE
2: PROGRAM PUTS A SOURCE WITH FIXED POSITION AT THE TARGET SCAN
   ANGLE AND ADDS OTHER SOURCES AS APPROPRIATE
3: SAME AS STYLE 2, BUT TARGET SOURCE POSITION IS ALLOWED TO VARY
   ENTER STYLE (A NUMBER FROM 1 TO 3)
2

YOU CAN SELECT WHICH GROUPS OF SCANS IN YOUR DATA FILE TO ANALYZE
ENTER THE 1ST AND LAST SCANS (FORMAT 2I5)
JUST HIT RETURN TO ANALYZE ENTIRE FILE
1,1

THE PROGRAM MAY HAVE DIFFICULTIES PRODUCING AN ACCEPTABLE FIT IF THERE
ARE BRIGHT SOURCES (>25 COUNTS/SEC) IN THE DATA.
THE PROGRAM WILL ELIMINATE REGIONS TOWARD THE ENDS OF THE SCANS
CONTAINING SOURCES BRIGHTER THAN "SMAX".
ENTER SMAX (FORMAT F10.0).  DEFAULT VALUE IS 75.
75.0

THE PROGRAM PRODUCES AN ESTIMATE OF THE BRIGHTNESS OF THE TARGET SOURCE
BY FILTERING THE DATA NEAR THE TARGET SOURCE POSITION.
DATA ARE USED IF THE COLLIMATOR RESPONSE TO THE SOURCE IS GREATER THAN
"WMIN".  ENTER WMIN (FORMAT F10.0).  DEFAULT VALUE IS 0.4.
0.4

THE PROGRAM INSERTS NEW SOURCES IN THE FIT MODEL
IF THEIR SIGNIFICANCE IS > THAN "SRCSIG"
ENTER SRCSIG (FORMAT F10.0).  DEFAULT VALUE IS 3.0
3.0

ENTER 1 TO USE SIMPLE TRIANGULAR COLLIMATOR RESPONSE
DEFAULT IS SMEARED TRIANGLE.
0

TYPE 1 TO ENTER NON-STANDARD COLLIMATOR SIZE
0

YOUR SCAN FILE CONTAINS THE SCAN ANGLE OF THE TARGET SOURCE.
AN OFFSET ANGLE, WHICH WILL BE ADDED TO THAT SCAN ANGLE,
CAN NOW BE ENTERED.  THE OFFSET IS IN DEGREES (FORMAT F10.0)
DEFAULT VALUE IS 0.
0

ENTER DISC FILE NAME (FORMAT 60A1)
dsdisk.tmp

     IREC, TITLE = 1       arcturus

    1.    169.00   -2   5.542   0.567   1.294   142.677
    2.     96.96   -3   5.661  -0.052   0.699   142.938
    3.     90.07   -4   5.656  -0.050   0.742   143.249
```

```
     4.    89.67   -5   5.652   0.043   0.794   143.301
     5.    89.67   -6   5.652  -0.043   0.794   143.299

FORTRAN STOP
$
```

The line-printer output is found in the AUTSCN.OUT file; the output file AUTSCN.TMP will be used as input for other data processing programs. The output from this AUTSCN run, Example 1, is included in the appendix (APP6 - 5) following this chapter.

6.3.3.2 The SCAN Program

The SCAN program utilizes scanning data files created by the DSDISK program. This program is used to determine the position and extent of sources observed by the HEAO A-2 satellite. It can calculate chi square fits to a point source model or to a variety of extended source models (box source, Gaussian, or King model). It can also be used (in "auto" mode) to determine the boundaries of a source error box. For the processing of many source files, please refer to Section 6.3.3.1, The AUTSCN Program.

The user is cautioned that the SCAN program finds a local minimum in chi-square. This may not be the "best" fit to the data for a given model. The program requires appropriate initial guesses for model parameters, and checking that the local mimimum appears to yield a reasonable fit.

6.3.3.2.1 Discussion of the SCAN Options

ENTER DISC FILE NAME
The input file should be in the "scan" format such that it can be analyzed by the programs: SCAN, AUTSCN, or PLTCAT. Output from the DSDISK program (dsdisk.tmp) is in the appropriate format.

INPUT RECORD NUMBER IN FILE (DEFAULT=1)(EXPECTS LE 999)
The program will process only one record in a file as the default. The user should enter the number of records that are to be analyzed. If the user enters "N" as the number of records in the file, where "N" is actually less than the real number of records in the file, the program will continue and ONLY process "N" records.

NBIN-SCNMIN-SCNMAX 100 136.25 161.25
These numbers are generated by the program and represent: the number of scan angle bins (usually 100), the minimum scan angle, and the maximum scan angle; these values have been determined from the input data record.

ENTER 1 TO USE SIMPLE TRIANGULAR COLLIMATOR RESPONSE
DEFAULT IS SMEARED RESPONSE.
BLEE

IF YOU WANT TO ENTER NON STANDARD COLLIM. SIZE, TYPE 1
Each SCAN-type data record produced by the DSDISK program identifies the HEAO A-1 detector number (1-6) and the Discovery Scalar (1-8) that were used to generate the data. The SCAN and AUTSCN programs assume the following FWHM values as standard collimator sizes (reference: thesis of R. Shafer, p. 27).

Detector	Odd DS (degrees)	Even DS (degrees)
HED 1	2.85	5.78
HED 2	2.91	5.92

MED	2.94	1.40
HED 3	2.91	1.47

If the user enters "1" to the previous prompt, the following will appear:

ENTER COLLIM. SIZE IN DEG.
The user may now enter a collimator size.

ENTER START-STOP BINS (DEFAULT=ALL)
All bins (100) will be used in determining the chi square fit; this is the default. If the user does NOT want to use all of the data for the fit, new bin boundaries may be entered. This is one way of eliminating isolated sources from the scan data without the need of fitting them.

INPUT RA,DEC(1950),EXTENT, AND EXT TYPE FOR FIXED SOURCE 1
Both this prompt and the next prompt are attempting to set up a model with which to fit the data. With this prompt, the fixed source is NOT assumed to be located on the scan plane; the program will compensate the source intensity for fixed sources not being directly on the scan plane. The RA, DEC, and Extent are in decimal degrees; if the extent is "0", a point source is assumed. The extent types are as follows:

0 = box source : model parameter is the full width of the box.
1 = gaussian : model parameter is sigma.
2 = King mode : model parameter represents core radius.

If the user does not want any fixed sources in addition to the main source, press the <CR> key. The program will continue to prompt the user concerning fixed source information until a <CR> is input instead of coordinate data.

INPUT NO. OF NEW POINT SOURCES, NEW EXTENDED SOURCES, AND THEIR TYPE
The user is being asked to input the number of point sources, the number of extended sources, and the type of the extended source. If the default of "0" is used, the user is indicating that there are no sources within the 25 degree scan angle. Enter only "1" to indicate the (original) point source; enter a number greater than "1" if point sources other than the original point source may be located within the 25 degree scan angle. The types of the extended sources are the same as in the previous prompt. All input extended sources are assumed to be of the same type.

SOURCE SCAN ANGLES: 149.259 0.525 MIN-MAX SCAN ANGLES 136.250 161.250
This message is displayed by the program. There is one message per data record analyzed.

TYPE 1 TO REINPUT SRCES
The user has the opportunity to enter different fixed sources. If the user answers "1" to this prompt, the program will return to the *INPUT RA,DEC(1950),EXTENT, AND EXT TYPE FOR FIXED SOURCE 1* prompt.

Now the user must set up the parameters to be fit.

TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 1

7.0000000 500.0000000 0.0000000 0.0010000

Displayed are the default values for the first parameter: the initial seed value, the upper limit, the lower limit, and the step size. The default values for the parameter can be changed by entering new values. The number of "parameters" that the user must set up depends upon the input data. A new value of "0.0" is ignored by the program; the old parameter value remains unchanged. A new value of "-1.0" sets the parameter value to "0.0". Setting the step size of a parameter to "0.0" fixes the parameter -- the program does not determine the best fit data.

The first parameter is the background level information; this parameter is always present. Every fixed source that has been specified will have one parameter for intensity. Every "new" point source will have two parameters: intensity and scan angle. Every "new" extended source will have three parameters: intensity, scan angles, and extent.

If the user has specified only one fixed source, the user will be prompted for two parameters: background intensity and fixed source intensity. If the user has specified one fixed source and one new point source, the user will be prompted for four parameters: background intensity, fixed source intensity, new point source intensity, and new point source scan angle. If the user has specified one new extended source, the user will be prompted for four parameters: background intensity, extended source intensity, scan angles, and extent.

No default values are supplied by the program for the scan angles, and it is the responsibility of the user to furnish this information.

START VALUES FOR PARAMETERS

7.000 5.000 5.000 5.000 0.000 ETC.

The number of values displayed depends upon the number of parameters that have been input by the user.

IF NOT HAPPY WITH PARAMETERS TYPE 1 TO TRY AGAIN

The default of "0" allows the user to proceed along with the program; an input of "1" will return the user to the *TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM 1* prompt. The user now has the opportunity to change the input values.

BEST FIT PARAMETERS AND CHISQ FOR 0 SOURCES

0.000 0.000 0.000 0.000

TYPE NO. OF CHI ITERATIONS AND DELTA CHI FOR QUICK EXIT,DEFAULT=10,.1

The user may determine the number of acceptable chi square iterations that the program should use.

At this point, the SCAN program will attempt to fit the data using the input model parameters and minimizing the CHISQ value.

ITER	*CHISQ*	*LAM*	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*
0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00

.
.
0 0.00 0 0.00 0.00 0.00 0.00 0.00 0.00 0.00

The determined CHISQ value will be displayed followed by a plot showing the data and the best fit.

TYPE 1 FOR PRINTOUT OF MODEL AND CHISQ

CONTINUATION OPTIONS: 0-REANALYZE, 1-CHANGE MODEL,
2-MORE DATA, 3-AUTO, 4-MANUAL, 5-PLOT DATA, 6-STOP

Option 0 : (default) reanalyze the data by returning to the *TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 1* prompt and proceed as usual.
Option 1 : return to the *INPUT RA, DEC (1950),EXTENT, AND EXT TYPE FOR FIXED SOURCE 1* prompt and proceed as usual.
Option 2 : close the current input file, and return to the *ENTER DISC FILE NAME* prompt and proceed as usual.
Option 3 : return to the *TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM 1* prompt. However, after the chi square input information, the program reverts to the *FOR AUTOPILOT: TYPE PARAM NO., START,STEP,NSTEP.NE.1* prompt. Toggle switch with Option 4. This will turn on the AUTOPILOT. AUTOPILOT steps through values for the selected parameter. Normally, the user wants to fix a specific parameter.
Option 4 : return to the *TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM 1* prompt and proceed as usual. Toggle switch with Option 3. This will turn off the AUTOPILOT.
Option 5 : plot the data and the fit. This allows the user a second opportunity to decide about the plotting of the data. If the plotting has already been turned on, it can be turned off. If the plotting has already been turned off, it can now be turned on.
Option 6 : exit the program.

FOR AUTOPILOT: TYPE PARAM NO.,START,STEP,NSTEP.NE.1

One can produce an error box for a selected source using the autopilot. The SCAN program will calculate the chi-square fits for the various fixed scan angles. If the user has picked a reasonable range of scan angles, a sufficient increase in chi-square on both sides of the best fit position will result. The user can decide the appropriate increase needed in the chi-square value to draw the confidence boundaries desired. The SCAN output will contain the information needed to construct a real (RA and DEC) error box. After each fit, the SCAN program will print out the values of several locations along the line of the position in the sky corresponding to the best fit scan angle.

6.3.3.2.2 Example Run of the SCAN Program

$ RUN [XRAY]SCAN

S C A N   VERSION OF 05-MAY-88

```
NOTE THAT DETECTORS COLLIMATOR SHAPE AND
DEFAULT FWHM'S HAVE BEEN CHANGED

OUTPUT WILL BE ON $DISK1:SCAN.OUT
ENTER DISC FILE NAME
dsdisk.tmp

INPUT RECORD NUMBER IN FILE (DEFAULT=1)(EXPECTS LE 999)
1

NBIN-SCNMIN-SCNMAX   100   136.25    161.25

ENTER 1 TO USE SIMPLE TRIANGULAR COLLIMATOR RESPONSE
DEFAULT IS SMEARED RESPONSE.
1

IF YOU WANT TO ENTER NON STANDARD COLLIM. SIZE, TYPE 1
0

ENTER START-STOP BINS (DEFAULT=ALL)
10,90

INPUT RA,DEC(1950),EXTENT, AND EXT TYPE FOR FIXED SOURCE 1
213.75,19.25

INPUT RA,DEC(1950),EXTENT, AND EXT TYPE FOR FIXED SOURCE 2
<CR>

INPUT NO. OF NEW POINT SOURCES, NEW EXTENDED SOURCES, AND THEIR TYPE
1

SOURCE SCAN ANGLES:  149.259 0.525  MIN-MAX SCAN ANGLES 136.250 161.25
TYPE 1 TO REINPUT SRCES
0

TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 1
     7.0000000   500.0000000  0.0000000  0.0010000
7.0,20.0,0.0,0.05

TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 2
     5.0000000  1000.0000000  0.0000000  0.0010000
5.0,1000.0,0.0,0.05

TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 3
     5.0000000  1000.0000000  0.0000000  0.0010000
5.0,1000.0,0.0,0.05

TRIAL VALUE,UPPER,LOWER LIM,STEP SIZE FOR PARM 4
     0.0000000  0.0000000  0.0000000  0.0000000
<CR>

START VALUES FOR PARAMETERS
7.000   5.000   5.000   0.000
IF NOT HAPPY WITH PARAMETERS TYPE 1 TO TRY AGAIN
```

0

BEST FIT PARAMETERS AND CHISQ FOR 0 SOURCES
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1000E+07
TYPE NO. OF CHI ITERATIONS AND DELTA CHI FOR QUICK EXIT,DEFAULT=10,.1
10,0.1

ITER	CHISQ	LAM	P1	P2	P3	P4	P5	P6	P7
0	7462.03	0	7.00	5.00	5.00	0.00			
					.				
					.				
					.				
7	152.24	0	5.00	5.00	5.00				

TYPE 1 FOR PRINTOUT OF MODEL AND CHISQ
1

CONTINUATION OPTIONS: 0-REANALYZE, 1-CHANGE MODEL,
2-MORE DATA, 3-AUTO, 4-MANUAL, 5-PLOT DATA, 6-STOP
6

The line-printer output from this SCAN run, SCAN.OUT, is included in the appendix (APP6 - 6) following this chapter.

6.3.3.3 The PLTCAT Program

The data contained in a "scan" file can be plotted using the PLTCAT program which generates up to six source plots per Versatec sheet. These plots give counts per second across the source region (typically summed over four days, for the default setting of DSDISK versus scan angle). The object name and date accumulation time are included in the individual plot headings.

$ RUN [XRAY]PLTCAT

A time message will be displayed. For example,

09:05:51

Prompt: ENTER MIN YMAX, MAX YMAX (DEFAULTS TO 1.,99999) <CR>

Prompt: INPUT DISC FILE NAME

Enter the name of the scan file. For example,

Type: DSDISK.TMP <CR>

Prompt: INPUT START-STOP RECORDS TO PLOT (2I5) DEFAULTS TO 1,999

<CR>

6.3.3.4 The LSTAUT Program

The LSTAUT program allows the user to generate various plots on the terminal screen based upon the output from the AUTSCN program; the AUTSCN.TMP file is used as input for this program. The possible plots are: Background vs Time, Flux vs Background, Flux vs Time, an Intensity Histrogram, and a Background Histogram. This program MUST be used on a graphics terminal in order to display the plots; no disk plot files are created. Lineprinter output can be found in "LSTAUT.OUT".

$ RUN [XRAY]LSTAUT

ENTER DISK NAME (^Z TO QUIT)
autscn.tmp

ENTER SELECTION CRITERIA:
ENTER BACKGROUND MIN. AND MAX (2F10.0) DEFAULT 0. TO 999.
0.0,20.0

ENTER TIME MIN,-MAX. DEFAULT 0. TO 999.
200.0,700.0

This option is allowing the user to select data from a period of time (in days of 1977) for analysis.

ENTER 1 TO USE FILTERED, RATHER THAN FIT INTENSITIES
1

An input of "0" (default) will determine the intensity of a source from the least squares fit. An input of "1" will determine the intensity of a source from the filtering of data near the source position.

If the user input "1" to the previous prompt, the following prompt will appear:

TO USE CONSTANT, RATHER THAN FIT BACKGROUND, ENTER 1
1

An input of "0" (default) will cause the program to determine the background intensity using a fit. An input of "1" will determine the background using the following input values.

ENTER BACK, TIME-MIN, TIME-MAX
5.0,200.0,700.0

ENTER INTENSITY MIN AND MAX. DEFAULT -100. TO 9999.
-100.0,100.0

ENTER MAX. ACCEPTABLE REDUCED CHI-SQ. DEFAULT IS 999.
2.0

Enter a reduced chi-square value. AUTSCN fits with reduced chi-squares larger than this value will be rejected.

ENTER MAX. ACCEPTABLE UNCERTAINTY IN INTENSITY.
DEFAULT IS 999.
2.0

ENTER 1 TO REJECT CONFUSED SOURCES
0

The preceding options allow the user to set up the full range of data that may now be accessed in whole or in part by the following plotting options.

ENTER 1 TO PLOT BACKGROUND VS. TIME
1

This is the first plot option you will receive. An input of "0" will cause the program to move on to the second plot option. An input of "1" will begin to prompt the user for information pertinent to the plot.

If the user chose "1" for the previous option, the following prompts will appear:

ENTER N, TIM-MIN, TIM-MAX (^Z TO END)
10,200.0,700.0

N is the number of bins for the x-axis, and TIM-MIN and TIM-MAX are the range in time (Days of 1977).

ENTER N, BMIN, BMAX
10,5.0,7.0

N is the number of bins for the y-axis, and BMIN and BMAX are the range in background intensity.

The user has now input the setup information for the first plot. The user will be prompted by the graphics package and should respond as in this example.

POSSIBLE GRAPHICS DEVICES:

P -- PRINTRONIX	*V -- VERSATEC*	*L -- LIACOM*
T -- TEKTRONIX	*5 -- VT152*	*Z -- ZETA*
A -- ARGS	*G -- GRINNELL*	*N -- NULL*

SELECT GRAPHICS DEVICE FOR CURRENT PLOT: T
WHICH TEKTRONIX TERMINAL IS FREE? <CR>

ENTER TITLE. 60A1
MYPLOT

The plot will now be displayed for the user on the terminal screen. The program pauses so that the user may make a hardcopy of the plot.

HIT RETURN TO CONTINUE
<CR>

ENTER N, TIM-MIN, TIM-MAX (^Z TO END)
^Z

The user may enter new values in order to replot the Background vs Time plot, or the user should enter a ^Z to move on to the second plot option.

ENTER 1 TO PLOT FLUX VS BACKGROUND
1

This is the second plot option the user will receive. An input of "0" will cause the program to move on to the third plot option. An input of "1" will begin to prompt the user for information pertinent to the plot.

If the user chose "1" for the previous option, the following prompts will appear:

ENTER N, BACK-MIN, BACK-MAX (^Z TO END)
20,5.0,7.0

N is the number of bins for the x-axis, and BACK-MIN and BACK-MAX are the range in background intensity.

ENTER N, FLUX-MIN, MAX
20,-1.0,1.0

N is the number of bins for the y-axis, and FLUX-MIN and MAX are the range in the flux.

The plot questions will now appear as explained in the previous prompt. Also, the plot will be displayed. The user can now make a hardcopy of the plot.

HIT RETURN TO CONTINUE
<CR>

ENTER N, BACK-MIN, BACK-MAX (^Z TO END)
^Z

The user may enter new values in order to replot the Flux vs Background plot, or the user should enter a ^Z to move on to the third plot option.

ENTER 1 TO PLOT FLUX VS TIME
1

This is the third plot option the user will receive. An input of "0" will cause the program to move on to the fourth plot option. An input of "1" will begin to prompt the user for information pertinent to the plot.

If the user chose "1" for the previous option, the following prompts will appear:

ENTER N, TIM-MIN, TIM-MAX (^Z TO END)

10,200.0,700.0

N is the number of bins for the x-axis, and TIM-MIN and TIM-MAX are the range in time (Days of 1977).

ENTER N, FLUX-MIN, MAX
20,-1.0,1.0

N is the number of bins for the y-axis, and FLUX-MIN and MAX are the range in the flux.

The plot questions will now appear as explained in the previous prompt. Also, the plot will be displayed. The user can now make a hardcopy of the plot.

HIT RETURN TO CONTINUE
<CR>

ENTER N, TIM-MIN, TIM-MAX (^Z TO END)
^Z

The user may enter new values in order to replot the Flux vs Time plot, or the user should enter a ^Z to move on to the fourth plot option.

ENTER EXCESS SIGMA (F10.0) (^Z TO QUIT)
0.0

EXCESS SIGMA: 0.000 WTD AV: 0.105 +- 0.094 XN: 1.424 AV.SIG: 0.188

This prompt will be repeated until the user enters a ^Z as input. The program adds the input excess sigma in quadrature to the error for each source intensity, performs a weighted average for the intensities, computes the chi-square for a constant intensity, and determines the average uncertainty (including the excess sigma). The user can continue to input excess sigma values until the reduced chi square (XN) is within an acceptable value range close to one.

ENTER 1 TO PLOT INTENSITIES (^Z TO QUIT)
1

This is the fourth plot option the user will receive. An input of "0" will cause the program to move on to the fifth and final plot option. An input of "1" will begin to prompt the user for information pertinent to this histogram plot. A ^Z will return the user to the initial prompt of *ENTER DISK NAME (^Z TO QUIT)*.

If the user chose "1" for the previous option, the following prompts will appear:

ENTER NBIN, XMIN, XMAX
10,-1.0,1.0

ENTER TITLE. 60A1
Source Plot

The plot questions will now appear as explained in the previous prompt. Also, the plot will be displayed. The user can now make a hardcopy of the plot.

HIT RETURN TO CONTINUE
<CR>

ENTER 1 TO PLOT BACKGROUND (^Z TO QUIT)
1

This is the fifth and final plot option the user will receive. An input of "0" will cause the program to move back to the fourth plot option for the Intensity Histogram. An input of "1" will begin to prompt the user for information pertinent to this histogram plot.

If the user chose "1" for the previous option, the following prompts will appear:

ENTER NBIN, XMIN, XMAX
10,200.0,700.0

ENTER TITLE. 60A1
Background Plot

HIT RETURN TO CONINUE
<CR>

The plot questions will now appear as explained in the previous prompt. Also, the plot will be displayed. The user can now make a hardcopy of the plot.

The two histogram plot options (4th and 5th plots) will continue to be redisplayed until the user inputs a ^Z. The program will then restart from the first prompt *ENTER DISK NAME (^Z TO QUIT)*. The user should enter a ^Z to quit the entire program.

ENTER DISK NAME (^Z TO QUIT)
^Z
FORTRAN STOP
$

The lineprinter output file for these sample input values (LSTAUT.OUT) can be found in the appendix following this chapter (APP6 - 8).

APPENDIX 6

APP6 - 1
Pre-defined Weights for the Discovery Scalars and the Anti-Coefficient Rate

USE STANDARD WEIGHTS FOR "TOTAL " RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 0.780	0.242	0.000	0.000	0.923	0.000	0.000	0.000	0.140
2 0.633	0.196	0.000	0.000	0.749	0.798	0.000	0.000	0.122
3 0.633	0.196	0.000	0.000	0.749	0.749	0.798	0.798	0.122
4 0.633	0.633	0.633	0.196	0.749	0.749	0.798	0.798	0.122
5 0.802	0.802	0.279	0.181	0.690	0.690	0.735	0.735	0.102
6 0.802	0.802	0.279	0.181	0.690	0.690	0.690	0.735	0.102

USE STANDARD WEIGHTS FOR "HARD " RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 1.236	1.939	0.000	0.000	0.000	0.000	0.000	0.000	0.115
2 1.236	1.939	0.000	0.000	0.000	0.000	0.000	0.000	0.115
3 0.944	1.329	0.000	0.000	0.000	0.897	0.000	1.293	0.099
4 0.944	0.944	0.944	1.329	0.000	0.897	0.000	1.293	0.099
5 0.000	2.845	2.361	1.418	0.000	1.118	0.000	1.700	0.182
6 0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

USE STANDARD WEIGHTS FOR "SOFT " RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 0.000	0.000	0.000	0.000	2.059	0.000	0.000	0.000	0.206
2 0.000	0.000	0.000	0.000	2.059	0.000	0.000	0.000	0.206
3 0.000	0.000	0.000	0.000	1.455	0.000	4.534	0.000	0.175
4 0.000	0.000	0.000	0.000	1.455	0.000	4.534	0.000	0.175
5 0.311	0.000	0.000	0.000	1.190	0.000	4.188	0.000	0.131
6 0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

USE STANDARD WEIGHTS FOR "R15 " RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 1.311	1.311	0.000	0.000	0.000	0.000	0.000	0.000	0.103
2 1.000	1.000	0.000	0.000	0.000	1.000	0.000	0.000	0.089
3 1.000	1.000	0.000	0.000	0.000	0.000	1.000	1.000	0.089
4 1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	0.089
5 1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	0.089
6 1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	0.089

USE STANDARD WEIGHTS FOR "WTD. R15" RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 1.171	0.364	0.000	0.000	0.000	0.000	0.000	0.000	0.087
2 0.952	0.295	0.000	0.000	0.000	1.201	0.000	0.000	0.074
3 0.952	0.295	0.000	0.000	0.000	0.000	1.201	1.201	0.074
4 0.952	0.952	0.952	0.295	0.000	0.000	1.201	1.201	0.074
5 1.207	1.207	0.420	0.272	0.000	0.000	1.333	1.333	0.050
6 1.207	1.207	0.420	0.272	0.000	0.000	0.000	1.333	0.050

USE STANDARD WEIGHTS FOR "MED M1 " RATE.

MODE			COLOR WTS.					ANTI-COEFFIC
1 0.000	0.000	0.000	0.000	2.053	0.000	0.000	0.000	0.205
2 0.000	0.000	0.000	0.000	2.053	0.000	0.000	0.000	0.205
3 0.000	0.000	0.000	0.000	2.053	2.053	0.000	0.000	0.205
4 0.000	0.000	0.000	0.000	2.053	2.053	0.000	0.000	0.205
5 0.000	0.000	0.000	0.000	2.053	2.053	0.000	0.000	0.205
6 0.000	0.000	0.000	0.000	2.053	2.053	2.053	0.000	0.205

DSDISK EXAMPLE RUN 1 -- Default Output

DSDISK.TMP -- Output disk file.

```
1136.75 0161.750  100  6  2 0.914020 0.372190 0.161373 0.405668-0.838575
-0.363628  378.088134766  382.082031250
5.731        0.209    149.26  Oarcturus  0.726  5
6.158        0.215
5.678        0.203
5.675        0.209
5.697        0.212
5.686        0.208
       .
       .
       .
5.781        0.220
5.742        0.211
5.062        0.194
5.943        0.224
5.756        0.212
```

DSDISK EXAMPLE RUN 1 -- Default Output

DSDISK.OUT -- Output lineprinter file

```
PROGRAM DSDISK VRS. 05-FEB-88
THE DATE IS:10-FEB-88 THE TIME IS: 15:11:00
"LINE PRINTER" OUTPUT IS IN "DSDISK.OUT"
OUTPUT DISK FILE IS "DSDISK.TMP"


PROGRAM USES "$DISK1:[XRAY]DSFET.D15" AS DATA BASE.
IGPTOT, IRNTOT =     967    11605
232.1 232.6 233.1 233.6 234.1 234.6 235.1 235.6 236.1 236.6 237.1 237.6
238.1
BETA =   0.600
START DAY FOR VIEWING IS:  235.0
   0 HAS BEEN ADDED TO EVERY IVIEW INPUT.
INPUT DISK=input.dat
USE STANDARD WEIGHTS FOR "TOTAL     " RATE.
MODE
                     COLOR WTS.                                      ANTI-COEFFIC
1   0.780   0.242   0.000   0.000   0.923   0.000   0.000   0.000   0.140
2   0.633   0.196   0.000   0.000   0.749   0.798   0.000   0.000   0.122
3   0.633   0.196   0.000   0.000   0.749   0.749   0.798   0.798   0.122
4   0.633   0.633   0.633   0.196   0.749   0.749   0.798   0.798   0.122
5   0.802   0.802   0.279   0.181   0.690   0.690   0.735   0.735   0.102
6   0.802   0.802   0.279   0.181   0.690   0.690   0.690   0.735   0.102

DETECTOR NO. (5=MED,6=HD3,7=COMBINED):  7

arcturus     213.750     19.250      0.000 0 0 0 0
ACCUM.TIME:  378.00   382.10 SCAN ANGLE:   149.26 MODE:  5
TIMES: 378.09 378.58 MODE: 5 DWT:  1.000 NO.EXP:     8.5
TIMES: 378.61 379.07 MODE: 5 DWT:  1.000 NO.EXP:     5.8
TIMES: 379.09 379.58 MODE: 5 DWT:  1.000 NO.EXP:     9.5
TIMES: 379.59 380.08 MODE: 5 DWT:  1.000 NO.EXP:    11.8
TIMES: 380.09 380.58 MODE: 5 DWT:  1.000 NO.EXP:    11.0
TIMES: 380.59 381.07 MODE: 5 DWT:  1.000 NO.EXP:    12.2
TIMES: 381.10 381.58 MODE: 5 DWT:  1.000 NO.EXP:     8.5
TIMES: 381.60 382.08 MODE: 5 DWT:  1.000 NO.EXP:     8.2
EFF:  0.726
```

DSDISK EXAMPLE RUN 2 -- Output

DSDISK.TMP -- Output disk file.

```
1 18.25 0 43.250  100  6  1-0.929575-0.338212-0.146641-0.368634 0.852846
 0.369816  560.588623047  561.572753906
8.564        0.901      30.74  larcturus  0.400  5
9.708        0.896
10.919        0.891
9.377        0.888
10.540        1.022
10.941        1.025
        .
        .
        .
9.677        0.891
9.656        0.890
11.118        1.038
12.404        0.954
10.323        0.990
```

DSDISK EXAMPLE RUN 2 -- Output

DSDISK.OUT -- Output lineprinter file.

```
PROGRAM DSDISK VRS. 05-FEB-88
THE DATE IS:10-FEB-88 THE TIME IS: 15:32:40
"LINE PRINTER" OUTPUT IS IN "DSDISK.OUT"
OUTPUT DISK FILE IS "DSDISK.TMP"


PROGRAM USES "$DISK1:[XRAY]DSFET.D30" AS DATA BASE.
IGPTOT, IRNTOT =      928    11137
232.1 232.6 233.1 233.6 234.1 234.6 235.1 235.6 236.1 236.6 237.1 237.6
238.1
BETA =    0.800
START DAY FOR VIEWING IS:  260.0
WEIGHT DATA BY DAILY EFFICIENCY
   0 HAS BEEN ADDED TO EVERY IVIEW INPUT.
MODE                 COLOR WTS.                                        ANTI-COEFFIC
1   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
2   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
3   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
4   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
5   0.900   0.900   0.300   0.200   0.700   0.700   0.740   0.740   0.201
6   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000


DETECTOR NO. (5=MED,6=HD3,7=COMBINED):  7

arcturus     213.750     19.250     0.000 1 0 1 0
ACCUM.TIME:  560.50  561.60 SCAN ANGLE:   30.74 MODE:  5
TIMES: 560.59 561.08 MODE: 5 DWT:  0.251 NO.EXP:    0.0
TIMES: 561.08 561.57 MODE: 5 DWT:  0.400 NO.EXP:    5.8
ATMP:  0.400  0.400  0.400  0.400  0.400  0.400
EFF:  0.400
TIMES: 561.61 562.08 MODE: 5 DWT:  0.548 NO.EXP:    0.0
TIMES: 562.08 562.56 MODE: 5 DWT:  0.697 NO.EXP:    8.7
ATMP:  0.697  0.697  0.697  0.697  0.697  0.697
EFF:  0.697
TIMES: 562.58 563.08 MODE: 5 DWT:  0.846 NO.EXP:    4.8
TIMES: 563.10 563.58 MODE: 5 DWT:  0.994 NO.EXP:    9.2
ATMP:  0.943  0.953  0.943  0.953  0.950  0.947
EFF:  0.948
TIMES: 563.58 564.08 MODE: 5 DWT:  0.857 NO.EXP:    0.0
TIMES: 564.08 564.58 MODE: 5 DWT:  0.708 NO.EXP:    7.7
ATMP:  0.708  0.708  0.708  0.708  0.708  0.708
EFF:  0.708
TIMES: 564.58 564.86 MODE: 5 DWT:  0.560 NO.EXP:    0.0
TIMES: 565.29 565.57 MODE: 5 DWT:  0.411 NO.EXP:    4.3
ATMP:  0.411  0.411  0.411  0.411  0.411  0.411
EFF:  0.411
TIMES: 566.17 566.57 MODE: 5 DWT:  0.114 NO.EXP:    5.7
ATMP:  0.114  0.114  0.114  0.114  0.114  0.114
```

EFF: 0.114

SORTRA EXAMPLE RUN 1 -- Output

SORT.TMP -- Output disk file.

```
arcturus      213.750     19.250    379.934 0 0 0 0 0 0 0 0     149.26
```

SORTRA.OUT -- Output lineprinter file.

```
SORTRA PROGRAM. VRS 22-JAN-88
THE DATE IS:26-FEB-88 THE TIME IS: 10:16:16
arcturus  1415 19.3   213.750    19.250   379.934  149.26
```

AUTSCN EXAMPLE RUN 1 -- Output

AUTSCN.TMP -- Output disk file.

```
arcturus  378.0881 382.0820 149.270 0.725  2  2  1  1  0 0
90.48     0.10  77  -6 0.400  4.3906  3.3338  2.4994E+01  1.3485E-01
5.652      0.023   -0.039     0.104    0.808    0.111  143.297    0.119
```

AUTSCN EXAMPLE RUN 1 -- Output

AUTSCN.OUT -- Output lineprinter file.

```
AUTSCN VRS. 02-MAY-88 RUN AT 13-MAY-88  10:17:43
MODE,STYLE,ISTOP =    2    2    0
PROCESS SCANS    1 THROUGH    1
SMAX =       75.0
MINIMUM EFFICIENCY FOR FILTERING:   0.400
MINIMUM SOURCE SIGNIFICANCE ("SRCSIG") IS:    3.00
USING SMEARED TRIANGULAR COLLIMATOR RESPONSE.
OFFSET ANGLE =      0.000
INPUT FILE IS dsdisk.tmp
**************
START DAY:  378.088 END DAY:  382.082 SOURCE: " arcturus "
SCAN   1 OF FILE: dsdisk.tmp
THERE ARE 100 BINS. BINS 10 THROUGH 90 ARE FIT.
SCAN ANGLES RUN FROM 136.750 THROUGH 161.750
TARGET IS AT ANGLE 149.270 COLLIM. FWHM =   1.412
ITERATION  5 CHISQ =      90.48  DOF =   77  LOG OF LAMBDA =    -6    -5
BKG =   5.652 +-  0.023 EFEXP =  0.7250
SOURCE  1 CPS =  -0.039 +- 0.104 AT ANGLE 149.270 OFF AXIS   0.000
SOURCE  2 AT ANGLE 143.297 +-  0.119 CPS =   0.808 +- 0.111
TARGET FILTERED INTENSITY =  0.053 +-  0.110
SUM OF EFF,EFF**2,C*EFF,(SIG*EFF)**2: 4.391E+00 3.334E+00 2.499E+01 1.34
9E-01
**************
```

SCAN EXAMPLE RUN 1 -- Output

SCAN.OUT -- Output lineprinter file.

```
S C A N               VERSION OF 05-MAY-88
RUN AT    5/23/88  14:57:51
X-Z   0.914020 0.372190 0.161373 0.405668-0.838575-0.363628
ANGULAR WIDTH OF DATA BINS:  0.250
START-END DAYS ACCUMULATION:  378.08813  382.08203
RECORD NO.   1 OF FILE: dsdisk.tmp
XDATA
5.731     6.158     5.678     5.675     5.697     5.686     5.642     5.652
                                .
                                .
                                .
5.929     5.628     5.515     5.497     5.569     5 [illegible]81     5.742     5.062
XERROR
0.209     0.215     0.203     0.209     0.212     0.208     0.205     0.204
                                .
                                .
                                .
0.214     0.199     0.211     0.212     0.209     0.220     0.211     0.194
USING SIMPLE TRIANGULAR COLLIMATOR RESPONSE.
FWHM OF COLLIM.:       1.412 DEG.
NO. OF BINS: 100 FOR SCAN ANGLES BETWEEN  136.750 161.750
BINS USED:  10  90
FIXED SRCE RA-DEC-EXT-TYPE  213.750   19.250    0.000  0
NO. AND TYPE FIXED SRCES:   1  0 NO. NEW SRCES:  1
NO. AND TYPE OF NEW EXTENDED SRCES:   0  0
SOURCE SCAN ANGLES:  149.261    0.087 MIN-MAX SCAN ANGLES   136.750 161.
750
START VALUES FOR PARAMETERS
7.000     5.000     5.000     0.000
CPS DATA=  462.91394 NPARM=          4
BEST FIT PARAMETERS AND CHISQ FOR   0 SOURCES
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1000E+07
ITER   CHISQ  LAM     P1              P2              P3              P4              P5
0    7462.03   0  7.0000         5.0000          5.0000        0.00000E+00
1    7462.03  -1  7.0000         5.0000          5.0000        0.00000E+00
RMS ERRORS:         0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
LOG OF LAMBDA  -1 DEG. OF FREEDOM:   77 CPSTRY=    594.280
VARIABLE SOURCE  1 AT SCAN ANGLE    0.000
RA AND DEC LINE
24.988    10.379    24.515  10.199   24.043  10.018   23.571   9.836
                                .
                                .
                                .
20.277    8.545    19.809   8.359   19.343   8.172
MODEL VALUES:
7.000     7.000     7.000    7.000    7.000    7.000    7.000    7.000    7.000
                                .
                                .
                                .
```

```
11.382   11.457  10.598   9.740   8.881   8.023   7.164   7.000   7.000
INDIVIDUAL CHISQ VALUES
 - FOR MODEL TOO LOW, + FOR MODEL TOO HIGH
52.10    49.83   30.57   59.17   10.78   39.72   22.18   53.14   30.30
                                 .
                                 .
                                 .
66.85 56.47 28.33
```

LSTAUT EXAMPLE RUN 1 -- Output

LSTAUT.OUT -- Output lineprinter file.

```
PROGRAM LSTAUT. 07-AUG-87 VRS. FEM
THE DATE IS: 8-MAR-88 THE TIME IS: 16:06:51
INTENSITY AND SIGMA HAVE BEEN CORRECTED FOR EFFICIENCY.
INPUT DISK: autscn.tmp
USING FILTERED INTENSITIES.
BACKGROUND MIN, MAX:      0.000    20.000
INTENSITY  MIN, MAX:   -100.000   100.000
REDUCED CHI-SQ  MAX:      2.000
INTENSITY SIGMA MAX:      2.000
TIME-MIN, TIME-MAX :    200.00    700.00
ASSUMED BACK.    TIME-MIN   TIME-MAX
5.000        200.00       700.00
SOURCE       VIEW 1  SCAN ANGLE BACK     +-     INT    SIG     XN  FLAG
arcturus  377.6 381.6 148.81  5.643  0.022   1.301  0.146   1.13
arcturus  561.6 564.9  30.73  5.663  0.035   1.011  0.202   1.57
RESULTS FOR FITTING BACKGROUND VS. TIME:
Y = (  5.6017E+00 +-  9.8921E-02 ) + X * (  1.0890E-04 +-  2.2510E-04 )
CHISQ =       0.00 FOR     0 DEG. OF FREEDOM    COR =    0.997
MEAN = (  5.6487E+00 +-  1.8626E-02 )
CHISQ =       0.23 FOR     1 DEG. OF FREEDOM
RESULTS FOR FITTING FLUX VS. BACKGROUND:
Y = (  8.3006E+01 +-  7.0459E+01 ) + X * ( -1.4479E+01 +-  1.2471E+01 )
CHISQ =       0.00 FOR     0 DEG. OF FREEDOM    COR =  -1.000
MEAN = (  1.2014E+00 +-  1.1850E-01 )
CHISQ =       1.35 FOR     1 DEG. OF FREEDOM
THE SUMMED INTENSITY OF   2 SOURCES IS: 2.312E+00 AV.= 1.156E+00
THE SUMMED VARIANCE AND ITS SQRT:  6.223E-02  2.495E-01
RMS VARIANCE:  1.764E-01
NO. OF SOURCES USED:   2 AV. RED. CHISQ:   1.349
2 POINTS. BACKGROUND WTD AV:  5.649 +-  0.019 XN:  0.234 AV.SIG:  0.026
```

7.0 Spectral Analysis

7.1 The GETPHAC Program

The GETPHAC program is the first program used to accumulate Pulse Height Analyzed (PHA) data. This program is used for pointing data and scanning data. The example in this documentation is a pointing data source.

7.1.1 Getting Started

Consult the tape list to determine the days and milliseconds in which the desired source was in the field of view. Next, check the Point Digital Status Output Catalog (time ordered by days of the year 1977) to obtain RAM, PHA, and channel mode (PHA limit) data.

Log onto a PDP 11/70 computer terminal. Refer to Section 3.2.1 for logon instructions.

At the prompt, *PDS>*, on the PDP 11/70,

Type: RUN DU0:[300,153]GETPHAC <CR>

Answer the following prompts accordingly.

Prompt: INPUT SOURCE RA AND DEC (1950),1 FOR DATA WITHIN 20 DEG

Enter the RA (right ascension) and DEC (declination) coordinates. For example,

Type: 187.35,13.03 <CR>

Prompt: INPUT STARTTIME,END TIME (DAY,MSEC),LAST CARD BLANK

Enter these times. For example,

Type: 538,49924000,538,72482000 <CR>

This prompt will be repeated. When it is redisplayed,

Type: 9999 <CR>

Prompt: INPUT 1 TO SELECT PHASE OF SOME PERIOD

<CR>

The following message will be displayed:

PROGRAM GOOD FOR ROM,RAMS1,3,10,9
DETECTORS FOR WHICH 10 OR 40S ARE VALID ACCUM TIMES:

MODE	10S	40S
ROM	ALL	ALL
RAM1	NONE	ALL

RAM3 NONE ALL
RAM10 3,5,6 ALL
RAM9 ALL ALL
INPUT 10 OR 40

Enter the appropriate PHA number. For example,

Type: 10 <CR>

Prompt: TYPE RAM #,0, 1 OR 2 FOR NO SUM, PER PASS OR SUM,1 TO EXCLUDE ROM

Enter the RAM number, method of summation, and the ROM number. The method of summation is indicated as follows:

If you enter '0', the spectra will not be summed, but instead, separate records will be written out at the accumulation time selected in the previous prompt.

If you enter '1', the spectra will be summed every time the satellite passed over the source.

If you enter '2', all spectra will be summed together.

Enter desired data. For example,

Type: 9,2,0 <CR>

Prompt:

INPUT DETECTOR,AMOUNT OF LEFT AND RIGHT
AND EITHER "32" OR "64" CHANNEL MODE (DEFAULT=64), 8CARDS

NOTE: The channel data is indicated in the PHA Limit column in the Point Digital Status Output Catalog. "Sep" means that the two layers of the detector were separated, each having 32 channels. "Com" means that the two layers of the detector were combined as one layer, thereby having 64 channels.

Enter this data. For example, type:

4,1,1,32
5,1,1,64
6,1,1,64

<CR>

Prompt: INPUT MIN SCAN ANGLE AND MAX SCAN ANGLE

<CR>

Prompt: INPUT MIN SCAN ANGLE AND MAX SCAN ANGLE

<CR>

Prompt: TYPE 1, IF YOU WANT A DISC FILE OUTPUT

Type: 1 <CR>

Prompt: INPUT DISC FILE NAME, INCL UIC(25A1)

Enter the file name and directory where you want the file to be stored. For example,

Type: DU0:[300,277]TEST.PHA <CR>

Prompt: DEFAULT=NEW OCCULT 2,1=OLD 2,10=NEW 1, 11=OLD1

<CR>

Prompt: EL FLAGS 1000. 800. 1200. 800. INPUT NEW IF WISH

<CR>

Prompt:

DATA FLAGS DEFAULT: USES PROD. FLAG AND ELCOM FOR EACH DET.

(GETSRC Tape) 1: USES PROD. FLAG AND ELCOM OF HED3
(GETSRC Tape) 2: USES QUIKL FLAGS, ELCOM FOR EACH DET
(MAX Tape) 3: USES QUIKL FLAGS, ELCOM OF HED3
(MAX Tape) 4: USES QLFLAGS FOR PROD MAX TAPES)

Enter the desired number. For example,

Type: 2 <CR>

Prompt: TYPE 1 FOR MCL LE 1.2, 2 FOR GT 1.2, DEFAULT FOR ALL

<CR>

Prompt: TYPE 1,1,JFIX,MGOOD, TO DISABLE HERRF AND/OR ACCUMT JFIX=5

NOTE: These fields are explained in Section 7.1.2.3, Discussion of Miscellaneous Input Parameters.

<CR>

Prompt: TYPE 1 TO FORGO OUTPUT OF COUNTS PER MF

NOTE: Unless you are looking at only a few major frames, use "1".

Type: 1 <CR>

Prompt: TYPE 1 TO RESET OR CTRL 2 TO EXIT

<CR>

Prompt: INPUT FILE # TO POSITION TO IF WISH

If you would like to use a specific input file, indicate it's number. For example,

Type: 2 <CR>

A job message will be displayed. For example,

```
****JOB22 - CONTINUED
    MOUNT 'MXTAPE' ON DRIVE
    MM1: **** TYPE CONT OR X TO ABORT
```

Mount your tape to the designated tape drive.

Type: CONT <CR>

The following message will be displayed.

```
MOUNT - **VOLUME INFORMATION**
          DEVICE    =MM1
          CLASS     =FOREIGN
          UIC       =[300,277]
          ACCESS    =[RWED,RWED,RWED,RWED]
          CHARAC    =[FOR,DCF]
```

The tape will be read. The following message will be displayed.

```
********END OF FILE 4 AND TAPE AT 436 77466790
DMO--MM1: ** DISMOUNT COMPLETE **
**** JOB22--CONTINUED
**TAPE MXTAPE DISMOUNTED FROM DRIVE 1**
```

Prompt: IS THERE ANOTHER TAPE?

Type: N <CR>

A job stop message will be displayed. For example,

```
JOB22 -- STOP
11:25:11  Size: 25K  CPU: 7:14.63
Status:  SUCCESS
```

7.1.2 GETPHAC Input Data

7.1.2.1 Channel Data

The background data should contain approximately the same number of seconds as the source data. Run the GETPHAC program. If there is very little or no background data in the background histogram, you will need to access or create and transfer background data from another file. The data in this file should be approximately the same time (+ or - 30 days) and approximately the same galactic coordinates (+ or - 5 degrees in b, + or - 20 degrees in l) as those used in the program.

To transfer background files, use the SAVE and UNSAVE commands. Refer to Section 7.1.2.2.

A file of 64 channel data may look like this:

```
MED 1 64x1   LEFT  1  RIGHT  1  436.84067 436.84113  DB0:D436.PHA
(det channels------sides------  start day  stop day    file name)
      40.8        0.0        0.0        0.0       0.0     0.0
0.0          0.0
(integration time followed by counts in each channel ----------------
-----)
       4.0        4.0        3.0        6.0       7.0    10.0    8.0
10.0
```

The file structure consists of a header which includes the following: the detector name, the number of source and background, the channel mode, left and right data, start time (in decimal day) and stop time, and the internal and external file names.

The first entry will contain the total time, in seconds, in the file and the number of counts in each PHA channel. The second half of the data is identical in format, e.g., having the same detector name and left/right channel. However, the second half of the data will contain different start/stop time, internal name and background.

7.1.2.2 Creating a Background File

To create a background file, run the GETPHAC program using a pointed observation where there is no strong (greater than or approximately 1/2 ct/sec) source in the field of view.

At the *PDS>* prompt, enter a command to edit a background file. For example,

Type: `EDI DB0:[300,111]X1954.PHA` <CR>

At the *PDS>* prompt, enter a SAVE command, indicating number of lines, the data base, and file name. For example,

Type: `SAVE 9 DU0:SAVE.TMP` <CR>

To exit, type: `EXIT` <CR>

7.2 THE HSPEC PROGRAM

This program is used for spectral analysis; it is a basic spectral fitting program for the HEAO A-2 experiment. HSPEC allows the user to compare Pulse Height Analyzed (PHA) data with selected spectral models, determining a "goodness of fit" in a chi-square sense.

There are three files that are used as input to this program: a PHA file (result of the GETPHA program), a ".crd" file, and an ".mat" file. These files are discussed in depth in the following section. In order to run the HSPEC program, the user must first run the TEMPLATE command file to create a TEMPLATE shareable image device driver which is attached to the current load module of the HSPEC program. The purpose of this is to assign the proper device driver (corresponds to the graphics output device) to the current terminal type. This file is temporary and only exists for the current logon session. Since the HSPEC program has a graphics option, it is necessary to execute this command file.

7.2.1 Discussion of the HSPEC Options

INPUT 1 FOR CARD FILE, 3 FOR CARDS
This prompt is looking for the mode of input that the user will use to tell the program how to group the detector channels: "1" denotes that a file exists which contains the necessary information; "3" denotes that the user will input the information interactively from the keyboard. Method "3" currently does not work.

INPUT CARD FILE NAME
The card file, ".crd", contains the information which tells the program how the user wishes to group the detector channels. These files are usually named to reflect the information that they contain. For instance, a file may be named "m3a64.crd": the "m" denotes the MED detector; the "3" denotes that the layers (1 and 2) should be combined; the "64" shows to use 64 channels; and the ".crd" shows that this is an ascii grouping card data file. An example of a ".crd" file can be found in the appendix (APP7 - 2) following this chapter.

INPUT MATRIX DISK FILE NAME-INCL UIC(25A1)
The matrix disk file, ".mat", contains the detector response which has been normalized to the total quantum efficiency at each energy. Essentially, it describes in what channels a photon of specified energy may be detected. These files are also named to reflect their contents. For example, a file may be named "m13n.mat": "m" denotes the MED detector; the "1" denotes the number of the MED detector; the "3" denotes that the layers (1 and 2) should be combined; the "n" denotes BLAH; and the ".mat" shows that this is a binary matrix response file. These files have been created by the HEAO A-2 project, and a list of the available files can be found in the appendix (APP7 - 3) following this chapter.

INPUT PHA DATA, DISC FILE NAME-INCL UIC(25A1)
The PHA data is the ascii source information file produced by the user through the use of the GETPHA program. A example of a PHA file can be

found in the appendix (APP7 - 4) following this chapter.

TYPE 1 TO ZERO BKGD
The default of "0" uses the background contained in the PHA data file. Input of "1" resets the background values to zero.

TYPE PER CENT BKG ERROR (DEFAULT POISSON), PER C SYS
The default of "<CR>" reflects that the errors follow a Poisson distribution. The user can also enter an error to be added in quadrature to the Poisson errors on the background and/or source counts. Those errors are input as relative errors (%).

INPUT START-END TIME OF DATA (DAY,MSEC)
DEFAULT 0,0,1000,0
The default of "0,0,1000,0" covers more than the entire lifetime of the instrument, days 0 - 1000. Input may be entered as 343,0,343,87969352.

CHOOSE ONE DETECTOR: PUT "1" UNDERNEATH
HD1 HD2 MED HD3
The user should choose the desired detector by placing a "1" beneath the detector name. Please note that the previous input data files should correspond to the current detector choice.

INPUT CHANNEL MODE (32 OR 64), LAYER,
AND AMOUNT OF LEFT AND RIGHT(1,0,-1)
Four input values are expected. The input depends upon the information given to the GETPHA program which produced the PHA data file. If the two layers of the detector were separated, each layer has 32 channels; if the two layers of the detector were combined, the combined layer has 64 channels.

> If the information has been improperly entered or does not correspond to the input data file information, the following appears:
>
> *CANT FIND SPECIFIED DATA SET*
> *TAKE REST OF DAY OFF; OR TRY AGAIN BY TYPING ONE*
> If "0" or <CR> is input, the program will exit.
> If the user inputs "1", the user is redirected to the *INPUT PHA DATA* prompt.

TYPE 1 TO COMBINE MORE DATA FROM SAME DATA SET
TYPE 2 TO COMBINE DATA FROM ANOTHER DATA SET
If "1" or "2" is entered here, the user is redirected to the *INPUT START-END TIME OF DATA (DAY,MSEC)* prompt in order to enter additional information.

INPUT SOURCE INTENSITY IN CTS/CM2/SEC
DEFAULT=1.
The program does not have sufficient information to determine the absolute normalization of the spectrum (it lacks the average effective area). Here, the user can enter the correct normalization.

PLACE A NONZERO REAL UNDER DESIRED FUNCTIONS

EXCEPT U. R CUTOF WHERE 1.=SIMPLE, 2.=E.BOLDT
3.=R.BUSSARD
OR UNDER THERML WHERE 1.=SIMPLE, 2.=FIGG
OR UNDER DISK WHERE 1.=EXACT DISK, 2.=APPROX.
THERM POWRL BLBOD LINES BOLTZ EDGES CUTOF COLLI MBBOD SCOMT GDXRB DISK SUNYV
The user needs to choose the type of model to be used to fit the data.
The choices are described as follows:

THERM: (for both SIMPLE and FIGG)
A1*THERML(A2)*ABS(A3) + A4*THERML(A5)*ABS(A6)

POWRL:
A1*POWRL(A2)*ABS(A3) + A4*POWRL(A5)*ABS(A6)

BLBOD:
A1*BLBOD(A2)*ABS(A3) + A4*BLBOD(A5)*ABS(A6)

LINES:
A1*LINE(A2=WIDTH,A3)*ABS(A4) + A5,A6,A7,A8 + A9*LINE(A10,A11)*ABS(A12)
NOTE WIDTH DEFAULTS TO 20. IF NOT DEFINED

BOLTZ:
A1 * E**A2 * EXP(-E/A3) * ABS(A4)

EDGES:
EXP(-A1 * (A2/E)**A3(DEF=2.7)) ABS EDGE

CUTOF: SIMPLE
EXP(-(E-A1)/A2) HIGH ENERGY CUTOFF

CUTOF: E.BOLDT
TAU=A1 CYCLOTRON E=A2 E.BOLDT HIGH E CUTOFF

CUTOF: R.BUSSARD
ATTEN(A1=B,A2=THETA,A3=NE,A4=PO,A5=IND,Z=.1,F=.5)

COLLI:
This function corrects for the fact that the collimators start to become transparent as E>=40 keV. Most users should not use this option.

MBBOD:
A1*BB(KT=A2)*ABS(A3)*XKAP**A4/(1+A5*XKAP**A4)

SCOMT:
A1*THERML(KT=A2,TAU=A3)*ABS(A4)

GDXRB:
NORM,ALF,GM,SG,ENU,ECMAX,ECMIN

DISK: EXACT DISK AND APPROX
NORM,T1,ABS

SUNYV:
ORM/E*SUNYV(E,TEMP,GAMMA,EMID)*ABS

INPUT INDEX FOR MODEL PARAMS IN GIVEN ORDER
The specific form of the model parameters as described in the previous prompt will be displayed. The values entered here represent only the INDICES of the input values; the actual values will be requested in the *TRIAL VALUES...* prompt.

IF NOT HAPPY WITH MODEL, TYPE 1
The default input of "0" means that the user is happy with the current model and number of parameters. Input of "1" will bring the user back to the *PLACE A NONZERO REAL UNDER DESIRED FUNCTION...* prompt and allow the user to choose a different model or a different number of parameters for a specific model.

BEST FIT VALUES:
0.0000E+00 ...
MIN CHISQ= 0.1000E+07

NOW SET UP FOR SEARCH ROUTINE.
LAMBDA 0.10000
IN THE FOLLOWING STEP =-1. TO KEEP PARAMETER FIXED
The user must depress the <CR> to proceed.

TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM 1
N.NNNNNNN N.NNNNNNN N.NNNNNNN N.NNNNNNN
This prompt will be repeated for the number of parameters chosen for the specified model. Displayed are the seed or trial value, the upper limit, the lower limit, and the step size for the specific parameter. Parameters can be changed by entering new values. As stated in the message preceeding this prompt, setting "STEP=-1." does not allow the parameter to vary. An input of "0" or "<CR>" allows the program to use the displayed default values.

START VALUES FOR PARAMETERS
N.NNNNNNN N.NNNNNNN ...
TYPE 1 TO RESET TRIAL PARAMETERS
Input of the default of "0" means that the user is content with the current trial values; an input of "1" brings the user back to the *TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM 1* prompt beginning at parameter value 1 and allows the user to input new values. The number of values displayed are the number of parameters chosen for the specific model.

IF NOT HAPPY WITH INPUTS TYPE 1 TO TRY AGAIN
Input of the default of "0" means that the user is content with the current input values; an input of "1" brings the user back to the *NOW SET UP FOR SEARCH ROUTINE* message and allows the user to input new trial values.

TYPE NO. OF CHI ITERATIONS AND DELTA CHI FOR QUICK EXIT, DEFAULT=10,.01
Input of the default values "10,0.01" or a "<CR>" means that a maximum of ten iterations will be performed, using "0.01" as the delta(chi) value test. This means that if the absolute value of the difference between the current chi value and the previous chi value is less than or equal to "0.01", it is assumed that the program has found the minimum

chi square value. The program will stop searching if it reaches the maximum number of input iterations or finds the minimum chi square value, whichever comes first.

FIT CPS=0.0000E+00 MORE CARDS=C, REANALYZE=A, NEW MODEL=P,
STOP=S,AUTO=T, MANUAL=F, PLOT=L

Input to this prompt MUST be entered as a capital letter, or the program assumes that the user has chosen Option A for REANALYZE. The options are as described below:

MORE CARDS=C	: The user is returned to the *INPUT PHA DATA, DISC FILE NAME-INCL UIC(25A1)* prompt.
REANALYZE=A	: The user is returned to the *BEST FIT VALUES:* message.
NEW MODEL=P	: The user is returned to the model choice prompt: *PLACE A NONZERO REAL UNDER DESIRED FUNCTIONS...*
STOP=S	: Proceeds to exit the program after asking about output information.
AUTO=T	: Autopilot mode. The user is returned to the prompt: *BEST FIT VALUES:...* After the chi information, the user will receive a message pertaining to AUTO mode: *FOR AUTOPILOT: TYPE PARAM NO.,START,STEP,NSTEP.NE.1.* The AUTO mode and MANUAL mode are toggle switches.
MANUAL=F	: Return the user to MANUAL mode from AUTO mode.
PLOT=L	: Plot the information.

IF YOU DESIRE PRINTED PHA OUTPUT OF LAST TRIAL MODEL: TYPE: P

If "P" is chosen, the counts/cm**2/s information for each channel group are appended to the output file. This information includes: data, fit, and sigma(fit-data).

7.2.2 Example Run of the HSPEC Program

*$* @template$root:shr

What TEMPLATE shareable-image device driver should be used?
ALP non-graphics alphanumeric terminals.
ANS non-graphics ANSI-standard terminals.
PTX Printronix printer/plotters.
TEK Tektronix 41xx series terminals.
GON Graph-ON terminals
: gon

$ run [xray]hspec

HSPEC OUTPUT TO UNIT 4 WILL BE ON $DISK1:HSPEC.OUT

INPUT 1 FOR CARD FILE,3 FOR CARDS
1

INPUT CARD FILE NAME
m3a64.crd

IS FLOPPY ON DRIVE 0 OR 1?

```
ANY OTHER INTEGER IF COMP MATRIX ALREADY ON DISC
2

INPUT MATRIX DISC FILE NAME-INCL UIC(25A1)
ml3n.mat

INPUT PHA DATA, DISC FILE NAME-INCL UIC(25A1)
cyg2pa.hph

TYPE 1 TO ZERO BKG
0

TYPE PER CENT BKG ERROR (DEFAULT POISSON),PER C SYS
0

INPUT START-END TIME OF DATA (DAY,MSEC)
DEFAULT 0,0,1000,0
0,0,1000,0

CHOOSE ONE DETECTOR: PUT "1" UNDERNEATH
HD1 HD2 MED HD3
         1

INPUT CHANNEL MODE(32 OR 64), LAYER,
AND AMOUNT OF LEFT AND RIGHT(1,0,OR -1)
64,1,1,1

TYPE 1 TO COMBINE MORE DATA FROM SAME DATA SET
TYPE 2 TO COMBINE DATA FROM ANOTHER DATA SET
0

INPUT SOURCE INTENSITY IN CTS/CM2/SEC
DEFAULT=1.
1.

PLACE A NONZERO REAL UNDER DESIRED FUNCTIONS
EXCEPT UNDER CUTOF WHERE 1.=SIMPLE, 2.=E.BOLDT
                             3.=R.BUSSARD
OR UNDER THERML WHERE 1.=SIMPLE,2.=FIGG
OR UNDER DISK WHRE 1.=EXACT DISK, 2.=APPROX.
THERM POWRL BLBOD LINES BOLTZ EDGES CUTOF COLLI MBBOD SCOMT GDXRB DISK
1.

INPUT INDEX FOR MODEL PARAMS IN GIVEN ORDER
A1*THERML(A2)*ABS(A3) + A4*THERMAL(A5)*ABS(A6)
1,2,3

IF NOT HAPPY WITH MODEL, TYPE 1
0

BEST FIT VALUES:
0.0000E+00 0.0000E+00 0.0000E+00
MIN CHISQ=  0.1000E+07
```

```
NOW SET UP FOR SEARCH ROUTINE.
LAMBDA      0.10000
IN THE FOLLOWING STEP =-1. TO KEEP PARAMETER FIXED
<CR>

TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM    1
   1.0000000       9.0000000      0.0001000    0.0010000
5.0

TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM    2
   1.0000000       9.0000000      0.0001000    0.0010000
0.1
TRIAL VALUE,UPPER,LOWER LIM,STEP FOR PARM    3
   1.0000000       9.0000000      0.0001000    0.0010000
0.001

START VALUES FOR PARAMETERS
   5.00000     0.10000     0.00100

TYPE 1 TO RESET TRIAL PARAMETERS
0

IF NOT HAPPY WITH INPUTS TYPE 1 TO TRY AGAIN
0

TYPE NO. OF CHI ITERATIONS AND DELTA CHI FOR QUICK EXIT, DEFAULT=10,.01
10,0.01

  P1     P2     P3     P4     P5     P6     P7     P8     P9     CHISQ
5.000  0.100  0.001  1.000  1.000  1.000  1.000  1.000  1.000 0.7215E+06
9.000      9.000  9.000  1.000  1.000 721219.63 1    -2
3.688      3.890  2.392  1.000  1.000 720280.88 2    -2
                        .
                        .
                        .
3.427      3.680  0.010  1.000  1.000    5255.92 9    -2
3.247      3.706  0.009  1.000  1.000    4415.48 10   -2
CPS = 0.925E+00
0.325E+01+-0.4E-02 0.379E+01+-0.13E-02 0.920E-02+-0.5E-04
FIT CPS=0.9253E+00      MORE CARDS=C, REANALYZE=A, NEW MODEL=P, STOP=S,
AUTO=T, MANUAL=F, PLOT=L
S

IF YOU DESIRE PRINTED PHA OUTPUT OF LAST TRIAL MODEL: TYPE: P
P

FORTRAN STOP
$
```

Sample output from this program run, HSPEC.OUT, are located in the appendix at the end of this chapter, APP7 - 5.

7.3 Calibration

7.4 Background Files

(A library of background files will be created at a future date).

7.5 RESPONSE MATRIX

The following is the list of the response matrix files considered to be the most useful set. The reference for this information is Dr. Jean Swank.

Dectector	File	Compressed File	Time Restraint
MED 1	med11224.mat	m11n.mat	
MED 1	med12224.mat	m12n.mat	
MED 1	med13224.mat	m13n.mat	
MED 1		m14n.mat	
HED 1	h111095.mat	h111095c.mat	
HED 1	h121095.mat	h121095c.mat	
HED 1	h131095.mat	h131095c.mat	
HED 1		h141095c.mat	
HED 2	h211095.mat	h21t.mat	
HED 2	h221095.mat	h22t.mat	
HED 2		h24t.mat	
HED 3	h311095.mat	h31257c.mat	<DOY304
HED 3	h321095.mat	h321095c.mat	<DOY304
HED 3	h331095.mat	h34257c.mat	<DOY304
HED 3		h33257c.mat	DOY304-DOY410, DOY490-DOY550
HED 3		h33448c.mat	DOY410-DOY490
HED 3		h33637c.mat	>DOY550

APPENDIX 7

M3A64.CRD

Example of a Grouping Card Data File

```
01 64
 RD1:[300,125]MED13224.      -.1039,.1372,.0000806
                  +++++++++++++++++++++++++++++++++++++++++++++++
```

```
***************************************************************
```

EXPLANATORY INFORMATION

```
      01 = use layer one
      64 = number of channels

MED13224 = MED detector
           1   = 1st MED detector
           3   = combined layers 1 and 2
           224 = compressed

-.1039,.1372,.0000806 = gain parameters

           + = start new bin with this channel
           - = add this channel to the previous bin
       blank = ignore this channel
```

CYG2PA.HPH

Example of a PHA Data File

```
 CYG2PA.HPH
HD2 1 32 X2   LEFT  1  RIGHT  0   539.79296   540.08310  DUO:CYG2PA.HPH
 951. 4     2006.0 40820.0   75534.0   62895.0   40227.0   24226.0
13601.0
                                 .
                                 .
                                 .
7386. 0     4057.0  2279.0    1289.0     737.0     429.0     262.0
227.0
HD2 2 32 X2   LEFT  1  RIGHT  0   539.79296   540.08310  DUO:CYG2PA.HPH
 951. 4       45.0   220.0    1486.0    3681.0     612.0     954.0
1469.0
                                 .
                                 .
                                 .
1516. 0     1366.0  1000.0     690.0     468.0     290.0     193.0
174.0
MED 1 64 X1   LEFT  1  RIGHT  1   539.79296   540.08310  DUO:CYG2PA.HPH
1376. 6       0.0     1.0       0.0       0.0       0.0       9.0
465.0
                                 .
                                 .
                                 .
1869. 0     2466.0  3996.0    6439.0    9989.0   14000.0   18095.0
21697.0
MED 2 64 X1   LEFT  1  RIGHT  1   520.60480   524.05042  CYG2B1.HPH
1638. 7      22.0     0.0       0.0       0.0       0.0       2.0
29.0
                                 .
                                 .
                                 .
 153. 0      178.0   198.0     275.0     324.0     384.0     436.0
470.0
HD3 1 64 X1   LEFT  1  RIGHT  1   539.79296   540.08310  DUO:CYG2PA.HPH
2098. 0       0.0     2.0    2298.0   18275.0   66430.0  114681.0
132188.0
                                 .
                                 .
                                 .
20453. 0   15557.0 11990.0    9419.0    7327.0    5472.0    4434.0
3451.0
HD3 2 64 X1   LEFT  1  RIGHT  1   520.60480   524.05042  CYG2B1.HPH
2056. 2      22.0     0.0     150.0     548.0    1054.0    1717.0
1869.0
                                 .
                                 .
                                 .
1978. 0     1854.0  1736.0    1516.0    1388.0    1300.0    1445.0
1092.0
```

HSPEC EXAMPLE RUN -- Output

HSPEC.OUT -- Output disk file

```
H S P E C       VERSION OF 4/22/88
RUN AT 15:37:17 ON  3-MAY-88
DISK FILE OF MATRIX AND CHANNEL CARDS IS m3a64.crd
GROUPS:   48
15 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
NUMBER OF CHANNELS=     63
                                                ***DET 1***
 DET      PHAMODE              GAIN PARAMETERS
 RD1: [300,125]MED13224.    64      -0.1039E+00   0.1372E+00   0.8060E-04
CHANNEL EDGE ENERGIES:
-0.1 7     -0.04     0.10     ...     0.65     0.79     0.93     1.07
1.2 1      1.35      1.48     ...     2.04     2.18     2.32     2.46
                              .
                              .
                              .
2.6 0      2.74      2.88     ...     3.45     3.59     3.73     3.87
GROUP EDGE ENERGIES
  1.9 0     2.04      2.18    ... 2.74      2.88     3.02     3.16
  3.3 1     3.45      3.59    ... 4.16      4.44     4.73     5.01
                              .
                              .
                              .
  5.3 0     5.58      5.87    ... 7.03      7.32     7.61     7.91
MATRIX DISC FILE:  ml3n.mat
CROSS SECTION PER GM HELIUM
1.10  0.356E+03  1.30   0.222E+03   ...   0.175E+03  1.52   0.150E+03
1.68  0.113E+03  1.76   0.995E+02   ...   0.970E+02  1.92   0.859E+02
                                     .
                                     .
                                     .
2.08  0.685E+02  2.16   0.616E+02   ...   0.555E+02  2.32   0.503E+02
DATA FILE NAME:  cyg2pa.hph
PER C BKGRD ERR    0. PER C SYS ERR    0.
START-END DAY OF DATA:     0.00000  1000.00000
DETECTOR IS:   MED
REQUESTED FILE: 64 CHANNELS, "LAYER"=  1 LEFT  1  RIGHT  1
SOURCE TIME:         1376.59998
GROUPED  SOURCE DATA:
21697. 0   24456.0   26036.0 ... 27700.0   27162.0   26996.0   26888.0
26986. 0   27757.0   28393.0 ... 27737.0   27271.0   26059.0   24808.0
45229. 0   40234.0   35458.0 ... 27284.0   23420.0   20359.0   17406.0
BACKGR TIME:         1638.69995
GROUPED  BACKGR DATA:
 470. 0     477.0     550.0  ...  472.0     539.0     478.0     482.0
 445. 0     485.0     498.0  ...  493.0     479.0     469.0     394.0
 808. 0     728.0     661.0  ...  586.0     522.0     463.0     448.0
TOTAL SOURCE TIME:   1376.600 BKGRD TIME:    1638.700
TOTAL SRCE CTS    802113.4 TOTAL SRCE CTS/CM2/SEC     1.000000000
```

```
NET CTS/CM2/SEC          ERROR
   0.026557557  +/-        0.000185037
   0.029989889  +/-        0.000196302
                 .
                 .
                 .
   0.031883232  +/-        0.000202658
   0.000056993  +/-        0.000017091
   0.000070908  +/-        0.000015867
MODEL BEING FIT IS:
P 1 * THERML(P 2) * ABS(P 3)
NUMBER OF TERMS=       3
START VALUES FOR PARAMETERS
 5.00000      0.10000      0.00100
P1           P2          P3          P4          P5         P6          P7          P
8          P9        P10      P11        CHISQ
.366E+0 1 0.356E+01 0.107E-01    ...    0.100E+01 0.100E+01 0.100E+01 0.
.343E+0 1 0.368E+01 0.988E-02    ...    0.100E+01 0.100E+01 0.100E+01 0.
                                  .
                                  .
                                  .
.325E+0 1 0.379E+01 0.920E-02    ...    0.100E+01 0.100E+01 0.100E+01 0.
FOR ITER =       10  LAMBDA=      -2 PARAMETERS=
.325E+0 1 0.379E+01 0.920E-02    ...    0.100E+01 0.100E+01 0.100E+01 0.
R.M.S. E RRORS:
.404E-0 2 0.285E-02 0.457E-04    ...    0.000E+00 0.000E+00 0.000E+00 0.
CPSOBS=  0.9305E+00 CPS FOR MODEL= 0.9253E+00
    CTS/CM2S CHAN GRP
DATA          FIT              #SIG(F-D)      K
.2656E- 01  0.2180E-01         -25.72        1
.2999E- 01  0.2716E-01         -14.43        2
.3188E- 01  0.3078E-01          -5.46        3
                        .
                        .
                        .
.1766E- 03  0.1007E-03          -3.82       45
.5699E- 04  0.7285E-04           0.93       46
.7091E- 04  0.5273E-04          -1.15       47
```

8.0 TIMING ANALYSIS

8.1 THE HRATE PROGRAM

The HRATE program extracts discovery scalar data from tape, calculates the count rate and corrects for the background and detector area. The output is the calculated, corrected count rates. The user controls the quality of the data accepted by the program by selecting one or more of the following conditions:

1) bit error checking
2) electron contamination check
3) clean flag check: earth occulation (earth + 100 km)
   high voltage instability
4) pointing data selection

The user also controls scan angle limits, data type (1.28 second, 5.12 second, or multiscalar), detector selection, and discovery scalar selection.

The HRATE program runs on the MicroVAX II computer system, utilizes MAX or GETSRC tapes, and generates an unformatted file of up to 4 rates at a time (background subtracted, efficiency corrected rates). For a pointed observation, the MAX tape for the day of interest or a GETSRC tape may be used. For 5.12 second data, the XRATE program using the XRATE database should be used.

For scanning data, to determine the days on which a desired source was in view, the user should run the SOURCE program (refer to Chapter 10.2). For pointing data, refer to the Point Status Book (located in the user's room) to determine the days on which a desired source was in view.

8.1.1 Discussion of the HRATE Options

The HRATE program requires the use of a 1600 bpi magnetic tape. Currently, there is only one tape drive attached to the MicroVAX computer, device MUA0. The user is responsible for mounting the data tape and putting the drive "on-line". The program will automatically allocate the drive to the user.

TO CREATE A DISK FILE, ENTER NAME NOW:
The user should choose an output disk file name which reflects information that it contains. Source_name.hrt is suggested; "source_name" is the object in question, and "hrt" shows that it was produced by the HRATE program.

INPUT SOURCE RA AND DEC (1950)
Input the RA and DEC of the source object in decimal degrees.

INPUT START-STOP TIME IF DESIRED, 4I8
The user should enter the day of the year and the time in milliseconds as integer vâlues: ddd,mmmmm,ddd,mmmmmm. This prompt will be repeated until a <CR> is issued. If no time period restriction is desired, press

the <CR>.

INPUT DATA TYPE BY "1." UNDER, "1.,9" for MULTI RAM9
1.28DSC 5.12DSC MULTISC
Four types of input data can be handled by the program: 1.28 second discovery scalar data (for RAMs 1, 3, 9, and 10), 5.12 second discovery scaler data (for ROM 1), 80 msec multiscaler data (for RAMs 1, 3, and 10), or 80 msec multiscalar data from RAM 9. The 80 msec multiscalar from RAM 9 must be treated in a special way for analysis. The user should choose the desired input by typing "1." beneath the data name. For the 80 msec multiscalar data from RAM 9, the user should type "1.,9" on the input line beneath the *MULTISC* option.

TYPE DET NO., (+ OR -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
There are no default values for the detector or the scalar numbers; data must be input for the detector and each of the four scalar value positions by the user. The value of "0" should be input as a scalar number as a "place-holder" in the event that the user wishes to utilize less than four discovery scalars. The user should enter the detector number, the scalar numbers, and the scan angle range (beginning degrees - ending degrees). If no scan angle limits are input, the scan angles are set from 0.0 to 360.0 degrees.

This prompt will be repeated four times: once for each type of possible input data. The detector numbers are: 1=LED 1, 2=LED 2, 3=HED 1, 4=HED 2, 5=MED, and 6=HED 3. The scalar values range from 1-8. Values 1-4 are unchanging and are defined as: 1=L1, 2=R1, 3=L2, and 4=R2 where L=left and R=right. The definition for values 5-8 can change and are formed from combinations of six pre-designed spectral windows: Layer 1 - 1A, 1B, 1C, and 1D; Layer 2 - 2A and 2B. Discovery scalars 5 and 7 are for the left; scalars 6 and 8 are for the right. The "+" and "-" in this prompt denote whether the discovery scalar data should be added or subtracted from the total. Some examples of input are:

3,1,3,0,0,47.0,52.5	HED1, Sum of Discovery Scalars 1 and 3, Scan Angle Limits 47.0 - 52.5
5,1,2,3,4,46.0,52.5	MED, Sum of Discovery Scalars 1, 2, 3, and 4, Scan Angle Limits 46.0 - 52.5
5,3,4,-7,-8	MED, Subtract Discovery Scalars 7 and 8 from the Sum of 3 and 4. For days 248-615, this would correspond to window 2A. No Scan Angle Limits

The user should be aware that only the center of each detector (not the entire field of view) will be constrained to be within the scan angle limits that the user enters. Thus, the y-axis will be required to be within the limits. The user must allow for the fields of view of each rate. Acceptable limits may be determined from the DSDISK output and the catalog of sources in the field of view for the specific observing time.

The background will be taken from regions that are within these scan angle limits, but with zero effective area on the source, unless the pointing option is chosen (see below). If the pointing option is not chosen, each file on the tape is read twice (for MAX tapes about 1/2 day): first to determine the background and second to determine the source rate using the background.

TYPE 1 FOR BIT ERROR CHECK
Input "1" to turn on the bit error check; "0" is the default.

TYPE 1 TO TEST EL FOR EACH DET, DEFAULT REQUIRES ONLY 1 EL FREE
Input "1" to turn on the electron contamination check; "0" is the default. For the default value of "0", if one or more detectors are NOT electron contaminated, data for ALL of the detectors is included for analysis.

TYPE 1 TO CALL CLEAN FLAG
Input "1" to turn on the clean flag check; "0" is the default. The clean flag for the MAX tapes deletes all MED data, so the user should not enter a value if using MED data.

A-CHOOSE MCL: 0 FOR ALL, 1 LE 1.2, 2 GT 1.2; B-MCL FILE
Dr. McIllwain mapped the earth's magnetosphere in coordinates of L and B which are roughly similar to radius and angle in spherical coordinates. It turns out that the best conditions for the X-ray environment are for small values of L (less than 1.2). Therefore, the user should usually input "1" when dealing with weak sources. The user should ignore part B of this prompt.

INPUT TRIAL OFFSET ANGLES 4 TIMES : Z,X;JFD;JBK
This input is used to change the detector offsets; the user should always use the default values by typing a <CR>.

INPUT NON-ZERO INTEGER IF POINTING DATA
Enter "0" if it is NOT pointing data. Enter "1" if the user wishes to input background values for either SCANNING or POINTING data, otherwise the program uses the scan angle limits input in a previous prompt to decide what data constitutes "background". Unfortunately, if the program should find no background data, it uses "0" as the background. Background data is considered to be anything within the specific scan angle limits which does not coincide with the source. Most users should input "1" and put in the background rates.

If the user input "1" to the previous prompt, the following prompt will appear:

INPUT BKGND RATE AND ERROR(CNT/SEC)* 1*
If the user chooses the default "0", the program uses scan angle limits input above to decide what data constitutes the "background". If the user inputs "1", the user must input standard background values (see the Standard Background table in the appendix following this chapter, APP8 - 1) for the detector configuration that has been chosen. The input error should be approximately 2%-3% of the background value. This prompt will be repeated four times, once for each of the possible four input data types.

TYPE 1 TO RESET

An input of "0" (default) allows the program to continue; an input of "1" sends the user back to the *INPUT SOURCE RA AND DEC (1950)* prompt.

At this point the program will begin to read the tape.

IS THERE ANOTHER TAPE?
If the user wishes to process another tape, type the capital letter "Y"; otherwise, the user should input "N".

Two files are output from an HRATE run: source_name.hrt and HRATE.OUT. HRATE.OUT is an ascii file containing the documentation parameters. Source_name.hrt is a binary file which is used as input to the HFOLD program.

This program automatically deallocates and dismounts the tape from the tapedrive. After a successful run of the program, the user needs only to remove the tape from the tapedrive.

8.1.2 Example Run of the HRATE Program

```
$ RUN [XRAY]HRATE

HRATE OUTPUT TO UNIT 6 WILL BE ON $DISK1:HRATE.OUT

%MOUNT-I-WRITELOCK, Volume is write locked
%MOUNT-I-MOUNTED, mounted on _MSA0:

TO CREATE A DISK FILE, ENTER NAME NOW:
f3c237.hrt

INPUT SOURCE RA AND DEC (1950)
186.6,2.3

SOURCE RA AND DEC (1950)     186.6     2.3

INPUT START-STOP TIME IF DESIRED, 4I8
533,81319708,533,84975388

INPUT START-STOP TIME IF DESIRED, 4I8
<CR>

INPUT DATA TYPE BY "1." UNDER, "1.,9" for MULTI RAM9
 1.28DSC 5.12DSC MULTISC
           1.

TYPE DET NO., (+ OR -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
6,1,2,3,4

TYPE DET NO., (+ OR -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE DET NO., (+ OR -) SCALAR NUMBERS,
```

AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE DET NO., (+ OR -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE 1 FOR BIT ERROR CHECK
1

TYPE 1 TO TEST EL FOR EACH DET, DEFAULT REQUIRES ONLY 1 EL FREE
1

TYPE 1 TO CALL CLEAN FLAG
1

A-CHOOSE MCL: 0 FOR ALL, 1 LE 1.2, 2 GT 1.2; B-MCL FILE
1

INPUT TRIAL OFFSET ANGLES 4 TIMES : Z,X;JFD;JBK
<CR>

INPUT NON-ZERO INTEGER IF POINTING DATA
1

INPUT BKGND RATE AND ERROR(CNT/SEC)* 1*
14.23,0.3

INPUT BKGND RATE AND ERROR(CNT/SEC)* 2*
<CR>

INPUT BKGND RATE AND ERROR(CNT/SEC)* 3*
<CR>

INPUT BKGND RATE AND ERROR(CNT/SEC)* 4*
<CR>

TYPE 1 TO RESET
0

FLAGS FOR ELECTRONS SET AT 1000. 800. 1200. 800.
INPUT NEW ELEC FLAGS (REALS), IF WISH
<CR>

The data tape is now begin read.

IS THERE ANOTHER TAPE?
N

Output HRATE.OUT from this example run of the HRATE program can be found in the appendix at the end of this chapter (APP8 - 2).

8.1.3 The DOMPRATES Program

This program dumps the 1.28 second data or the 80 msecond data from an HRATE file to determine whether the data may have overflowed. First, run the HRATE program to create a file which is used as input to this program. Next, run the DUMPRATES program.

```
$ RUN [XRAY]DUMPRATES
```

INPUT DISC FILE NAME

f3c237.hrt

INPUT START,END TIMES IN DAY, MSEC
(2I4I9),(DEFAULTS TO 0.,1000.)

533,81319708,533,84975388

The input time is echoed to the screen.

533 81319708 533 84975388

TYPE ANY INTEGER>0 FOR COUNTS RATHER THAN FLUX

1

The input integer is echoed to the screen.

TYPE 1 FOR 1.28S RATES, 0=80MS

1

The input value is echoed to the screen.

INPUT BACKGD CTS/S USED BY H/XRATE PROGRAM RUN (NOT
THE BACKGROUND CORRECTION)

5.000,0.0,0.0,0.0

Input the background values that were entered in the HRATE program run.

The counts are echoed to the screen.

5.000,0.0,0.0,0.0

The file will now be read.

8.2 THE XRATE PROGRAM

The XRATE program extracts 5.12 second rates from the scanning data. It uses the XRATES database which is accessed by the MicroVAX II computer; the XRATE database is stored on 1600 bpi tapes in the Building 2 computer room. Each tape covers about six days. Generally, one scan of a source is covered in one to three tapes.

The XRATE program has the capability of creating two types of output files: the standard XRATE output file, and an HRATE-type of output file. The HRATE-type file contains a header and a record for each 5.12 seconds of valid data. The record consists of: day, msec, area, rate, error, and rate id -- where the header defines the rate id. The XRATE output files consist of records: each record contains the value of the McIllwain L parameter, a flag as to whether the time passed all tests for being good data for the particular detector, and the standard information in XRATE records. This possibility was incorporated to allow making a file which included data which might be, but not necessarily was, suspect. The user could then examine both the entire and the restricted set.

For XRATE, the recommended method of dealing with the background is to select the POINTED data option and input nominal values for the background. XRATE reads the tape only once, uses the input constant background, but computes for each file what the background value really was between the scan angle limits and outputs the average background value, the variance, and the difference from the input value.

For scanning data, to determine the days on which a desired source was in view, the user should run the SOURCE program (refer to Chapter 10.2). For pointing data, refer to the Point Status Book (located in the user's room) to determine the days on which a desired source was in view.

The XRATE input prompts are very similar to the HRATE input prompts. For more information and explanation of the prompts, please see Chapter 8.1.1, Discussion of the HRATE Options.

As the HRATE program, the XRATE program requires the use of a 1600 bpi magnetic tape. Currently, there is only one tape drive attached to the MicroVAX computer, device MUA0. The user is responsible for mounting the data tape and putting the drive "on-line". The program will automatically allocate the drive to the user.

Similar to the HRATE program, the XRATE program deallocates and dismounts the tape from the tapedrive. After a successful program run, the user need only to remove the tape from the tapedrive.

8.2.1 An Example Run of the XRATE Program

```
$ RUN [XRAY]XRATE

XRATE OUTPUT TO UNIT 6 WILL BE ON $DISK1:XRATE.OUT
```

```
%MOUNT-I-WRITELOCK, volume is write locked
%MOUNT-I-MOUNTED, mounted on _MSA0:

IF WANT TO CREATE DISC FILE, TYPE 1
1

INPUT DISC FILE NAME
test.xrt

INPUT SOURCE RA AND DEC (1950)
213.75,19.25

SOURCE RA AND DEC (1950)      213.75    19.25

INPUT START-STOP TIME IF DESIRED
<CR>

INPUT DATA TYPE BY "1." UNDER, "1.,9" for MULTI RAM9
 1.28DSC 5.12DSC MULTISC
         1.

TYPE DET NO., (+ or -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
5,2,4,0,0,44.75,60.0

TYPE DET NO., (+ or -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE DET NO., (+ or -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE DET NO., (+ or -) SCALAR NUMBERS,
AND ANGLE LIMITS (DEFAULT=NONE)
<CR>

TYPE 1 TO TEST EL FOR EACH DET, DEFAULT REQUIRES ONLY 1 EL FREE
1

TYPE 1 TO RECORD EL FLAG AND L
1

A-CHOOSE MCL:0 FOR ALL, 1 LE 1.2, 2 GT 1.2; B-MCL FILE
1

TYPE 1 OR DEFAULT FOR JFD; JBK
0

TYPE 1 TO INPUT BACKGROUND
1

INPUT BKGD RATE AND ERROR*(CNT/SEC)*  1
3.94,0.0079
```

INPUT BKGD RATE AND ERROR(CNT/SEC)*   2*
<CR>

INPUT BKGD RATE AND ERROR(CNT/SEC)*   3*
<CR>

INPUT BKGD RATE AND ERROR(CNT/SEC)*   4*
<CR>

TYPE 1 TO RESET
0

The data tape is now being read.

IS THERE ANOTHER TAPE?
N

The yes/no answer to the previous prompt must be a capital letter "Y" or "N".

Two files are output from an XRATE program run: source_name.xrt and XRATE.OUT. XRATE.OUT is an ascii file that contains the input information. Source_name.xrt is a binary file which is used as input to the HFOLD program.

A copy of the output from this example run of the XRATE program is located in the appendix immediately following this chapter (APP8 - 3).

8.3 THE HFOLD PROGRAM

This is a disk program which utilizes input data from an HRATE report. This program is used for period finding and folding of data.

$ RUN [XRAY]HFOLD

INPUT DISC FILE NAME
arcturus.hrt

HFOLD OUTPUT TO UNIT 6 WILL BE ON $DISK1:HFOLD.OUT

PUT "01" UNDER RATE NOS. DESIRED
1 2 3 4
~~01~~
01

TYPE MIN EFFECTIVE AREA ACCEPTABLE, 1 FOR LC OF COUNTS
UPPER THRESHOLD
0.0,0,0.0

Three inputs may be entered here: minimum area; the switch for producing a light curve in units of intensity (Option=0) or in units of counts/second (Option=1); and the upper threshold value. Data with small effective area is very sensitive to incorrect background values and should be used with caution. Most users should enter a minimum area of approximately 50.0. If the user enters "1" for light curve of raw counts, no effective area correction will be made. The upper threshold is used to reject data with very high fluxes.

TYPE 1 FOR LIGHT CURVE OUTPUT
0

TYPE NBIN,REF DAY,PER,HALF WIDTH,STEP,D(0) OR S(1)
HALF WIDTH=0, STEP GT 0 FOR KINF=1 POSSIBLE
30,236.0,1.7,0.0,1.0,0

NBIN = number of fold bins, REF DAY = in days of 1977, PER = period, HALF-WIDTH = 0 if the user wishes to use less than 1000 points, STEP = step size, and D(0) or S(1) is whether the input period is in units of days (Option 0) or seconds (Option 1).

TYPE KINF,JDAY,(KINF=0 TO STEP PER)
JDAY=1 FOR TIME OF LAST READ
1

If the user enters "1", the data will be read once. KINF (K infinite) should equal "1" if more than 1000 points are needed; KINF should equal "0" if less than 1000 points are needed.

JDAY should equal 1 if you wish to specify intervals to be folded separately.

TYPE JDOP, JMOD, JMORE
0,0,0

If doppler shifts are needed, enter 1 under JDOP. If the user wishes to select a phase, enter 1 under JMOD. If the user wishes to be able to reset periods for one finite dataset (less than 1000 points), enter 1 under JMORE.

If the JDOP=1 option were chosen, the following prompt appears:

TYPE BIN PER(DAYS), ECL TIME(DAYS), ORB SIZE (SEC)

If the JMOD=1 option were chosen, the following prompt appears:

TYPE MODULATION PER(DAYS), REF DAY, START PHASE, END PHASE

INPUT TIME INTERVALS IF DESIRED,DAY,MSEC,UP TO 10
0

The chi-square for the data folded for the selected period will be displayed. Every time you press the enter key, the original period will be incremented by one step (for example, one second).

The printed output will contain reduced chi-square values and other relevant data.

OLD D:0=P+DP, 3=NEW P; NEW D:1=NEW P, 2=OLD P; 4=END

The user may now use the HFOLDP program to fold the data onto the best period (with the highest chi-square).

8.4 THE PLOTLC PROGRAM

PLOTLC is a graphics program which creates a plot from the output of the HFOLDP program, as well as from formatted ascii files created by the user. This program requires two input files to run: a data file and a parameter file. The data file can be either the output from the HFOLDP program or a formatted ascii data file; the parameter file is an ascii file created by the user containing the plot options desired to display the data. Output from this program is in the form of a plot which can either be sent to the terminal screen or sent directly to the laserprinter, and chi square information sent to the terminal screen.

8.4.1 Discussion of the Parameter File Input

The parameter file contains data which specifies the type and style of the plot output generated by the PLOTLC program. The parameter file must be set up in order as follows:

C = character string, I = integer, R = real

1. (C) input file name
2. (1I) type of file (0=HFOLDP output, 1=free format data)
3. (6I) term numbers in the following order:
   x-array, sigma x, y1, sigma y1, y2, and sigma y2. There should be an input value for each of the above data types. A "0" denotes that the data is not present; a value ("1", "2", etc.) denotes which data vector contains the variable.
   HFOLDP files are unformatted sequential files of the form:

   Header: # of light curve bins, period=length of x-axis, and # of light curves in file.
   Data:
   y1   sigmay1   y2   sigmay2   [ratio   sigma ratio]

   The data in brackets is not always present. For HFOLDP files, the x-axis runs from zero to the Period, and the light curve is divided into NBIN bins of equal size so
   x(i) = (i-0.5)*(Period/NBIN);
   the x-array and the sigma x-array are never read in when plotting an HFOLDP file.
4. (3R) definition of linear operations: type, a multiplicative constant(slope), and an additive constant(offset).
   TYPE
   0.0   y1
   1.0   slope*y1 + offset
   2.0   slope*y1 + y2 + offset
   3.0   slope*y1*y2 + offset
5. (2I) function choice
   The selection is as follows:
   0 = no fit
   1 = chi square fit to a constant and a line
   2 - 4 = same as "1", but does not include points where sigma(point) > (2-4)*mean_sigma
   >9 = excludes points outside of the user defined x and y limits

when autoscale is not requested.

6. (3I) # of bins, # of header lines in data file, # of terms per line of data. This information is NOT used for HFOLDP format files.
7. (2I,4R) switch to rescale x, switch to rescale y, new xmin, new xmax, new ymin, new ymax (switch: 0=no, 1=yes)
8. (2I) format of data (1st and 2nd line)
   1st line:
   - 0 = error bars only
   - 1 = line plot
   - 2 = histogram
   - 3 = histogram and y-error bars

   2nd line:
   - -1 = no second line
   - 0 = dashed line at y=0
   - 1 = plot best fit mean
   - 2 = plot best fit linear model
9. (C) x-label (in single quotes)
10. (C) y-label (in single quotes)
11. (2I) bottom margin, top margin in tenths of inches (approximately) (must experiment with this option)
12. (1I,2R,1I) shrink switch, x-fraction, y-fraction, location (switch: 0=no, 1=yes; 0.0 < fraction < 1.0) (must experiment with this option)
13. (3I) # of x-windows, # of y-windows, window for plot The origin (1,1) is the lower left-hand corner.
14. (1I) type of output device. Negative values denote a printer; positive values denots a terminal.
    - 3 = terminal screen (Tektronix 4010/4014)
    - 6 = Sun windows
    - -5 = laserplot (portrait mode -- long axis is vertical)
    - -6 = laserplot (landscape mode -- long axis is horizontal)

Each numbered line represents one line of input data.

8.4.2 Example Parameter File and Explanation

```
Line  1.  H212OP55.LTP
Line  2.  0
Line  3.  0  0  1  2  0  0
Line  4.  0.0  0.0  0.0
Line  5.  1
Line  6.  500  0  3
Line  7.  0  1 -1000.0 7000.0 -0.05 0.10
Line  8.  3  0
Line  9.  '       TIME IN SECONDS '
Line 10.  '          HED3 CTS/CM\U2-S '
Line 11.  35  15
Line 12.  0  0.75   1.00   0
Line 13.  2  1  2
Line 14.  -6
```

The line numbers (Line 1.) are NOT part of the file but are provided for correspondence to the following explanations.

```
Line  1.  name of input data file
Line  2.  0 = HFOLDP file
Line  3.  input data: y1 (vector 1) and sigma y1 (vector 2)
Line  4.  type 0.0, slope=0.0, offset=0.0
Line  5.  Chi square fit to a constant and a line
Line  6.  not used for HFOLDP files: nbin, # header lines,# of plots
Line  7.  rescale y-axis to -0.05 - 0.10
Line  8.  histogram with y-error bars and a dashed line at y=0
Line  9.  input x-axis label
Line 10.  input y-axis label
Line 11.  bottom margin of 35x0.1" and top margin of 15x0.1"
Line 12.  do not shrink plot
Line 13.  2 x-windows, 1 y-window, plot in second x-window
Line 14.  laserplot in landscape orientation
```

8.4.3 Example Run of the PLOTLC Program

```
$ run [xray]plotlc
INPUT PARAMETER FILE NAME: plotlc.par
   H2120p55.ltp

 NBIN =    59PER=    302.08        1LCS
   Y, SIGY, for each light curve:
   1 0.2560E+01  0.2560E+01  0.4483E-03  0.1174E-02
                             .
                             .
                             .
chisqr & dof 1498.1  58 for mean, sigmean: 0.2924E-02  0.1785E-03
chisqr & dof 1232.4  57 for slope, intercept: -0.3436E-04  0.8812E-02
```

The plot will now be displayed on the terminal screen or sent to the laserprinter, depending upon the option chosen by the user (Line 14 of the parameter file). The user should be aware that the way the plot appears on the screen may NOT be the way that the plot is generated by the laserprinter. Some adjustments may have to be made by the user for the proper laserprinted output.

8.5 The MURD Program

The MURD program is used to search for periodicity in data. You will be using data from an HRATE or XRATE data file with this program.

A Vector General plot will be generated, and will give a fairly good idea of possible periods which can then be tested using the HFOLD program. The HFOLD program will allow you to test various periods in order to obtain the largest chi-square from a folded set of data when tested against the hypothesis of its being constant.

Log onto a PDP 11/70 computer terminal. Refer to Section 3.2.1 for logon instructions.

At the prompt, *PDS>*,

Type: RUN RD1:[300,147]MURD <CR>

Prompt: ACCUMULATION INTERVAL (SECS) -->

Normally, you would use .08, 1.28, 5.12, or 1800. intervals for 1 bin per revolution. Data is usually accumulated in intervals of .08, 1.28, and 5.12s. If you prefer to use one bin per scanning revolution, you may want to use 1800.s (about 30 seconds). For example,

Type: 1800. <CR>

Prompt: START DAY, MS, STOP DAY, MS <CR>

Type in the start stop time of the data you want to Fourier transform. For example,

Type: 286,7500000,304,7500000 <CR>

Prompt: A,R1,R2,R3,R4 . . . 1 FOR AREA . . . 4 RATES <CR>

Enter rates. For example,

Type: 0,1,, , <CR>

Note: In this example, the scientist chose not to correct the effective area, and requested rate 1.

Prompt: DS NAME

Enter the name of the HRATE or XRATE data file you are using. For example,

Type: DU0:[300,153]LM712X1B.HRT. <CR>

Prompt: LEVEL?

Press the <CR> key.

program will print above it the period in minutes, plus the probability of exceeding the power in that period by chance.

Prompt: ENTER YMAX OR CNTRL Z TO QUIT

If you enter YMAX, the Y axis will be rescaled on the VG screen using this as the maximum Y value.

The MURD program allows you to Fourier transform the effective area differences in the data. MURD also oversamples the data by a factor of 3, which may sometimes be convenient for finding the true period.

8.6 The FFTSUM Program (on the NSSDCA Vax 8650, using a MacIntosh Terminal)

The purpose of the FFTSUM program is to allow the user to perform fourier data analysis on scanning data, calculating period, probability, and power values. The FFTSUM program also allows the user to plot the resulting power spectrum. In the scanning mode, the experiment views a source for approximately one minute and may view it again approximately thirty minutes later. FFTSUM produces a power spectrum for each scan and adds them together (phase coherence between scans is lost). First, run the HRATE program to extract discovery scalar data and calculate count rates. Next, use your HRATE file as an input file with the FFTSUM program. Refer to Section 12.0, Useful Procedures, for instructions on transferring files from the PDP 11/70 computer to the NSSDCA Vax 8650.

Using a MacIntosh terminal, log onto the MicroVax II computer. Refer to Section 3.0 for logon instructions.

At the $ prompt, type: SET HOST NSSDCA

The NSSDCA Vax 8650 Welcome Screen and logon messages will be displayed. Answer the following prompts accordingly.

USER ID: NETZER
PASSWORD: HAGAI001

Prompt: $

Type: TPL <CR>

This will invoke the TEMPLATE graphics package. Hardware device names will be displayed.

Prompt: :

Type: SHR <CR>

This requests the sharable image mode.

Prompt: FILENAME:

Enter the program file name. For example,

Type: FFTSUM <CR>

Prompt: DO YOU WANT TO COMPILE?

The .OBJ file of all FFTSUM subroutines already exists, so it is unnecessary to compile.

Type: N <CR>

Prompt: DO YOU WANT TO LINK?

The FFTSUM.EXE ecution file already exists, so there is no need to use this option.

Type: N <CR>

Prompt: HOW ABOUT RUNNING?

Type: Y <CR>

The device names will be displayed. Select the TEK terminal device emulator by answer the next prompt accordingly.

Prompt: :

Type: TEK <CR>

Prompt: LETS [illegible]N FFTSUM
ENTER [illegible] OF DATA POINTS, EG..08,1.28,5.12 S

Enter the time bin (in seconds) of the data points. This is the same as the data type selected in HRATE or XRATE. For example,

Type: 5.12 <CR>

Prompt: ENTER NAME OF HRATE FILE

Enter the name of the HRATE file that you wish to use as an input file with this program. For example,

Type: S0115.HRT

Prompt: LIST VALID RATE IDS. THEY RANGE FROM 1 TO 4.

The user will have the option of utilizing up to four rates at one time. For example,

Type: 1,0,0,0

Prompt: ENTER NO. OF SCANS TO BE READ
SCANS TO SKIP (2I10)

First enter the number of scans to be read. Next, indicate the number of scans to be skipped. For example,

Type: 50,0 <CR>

Prompt: ENTER MINIMUM AVERAGE FLUX TO USE SCAN

Type: <CR>

The following message/prompt will be displayed:

0.00000 IS THE MINIMUM FLUX TO USE A SCAN
ENTER MINIMUM NUMBER OF DATA POINTS TO USE

Enter the number of the desired group of data points. For example,

Type: 20 <CR>

Scan data will be displayed on the screen. For example,

```
SCAN STARTING AT   1852.67  HAS  23 DATA POINTS.
NMAX,NDATA, IE:    1024     47     0
AVERAGE FLUX =   0.06959 FOR 47 DATA POINTS.
etc...
```

At the end of the data, the number of scans summed and the mean power will be indicated. For example,

```
NO OF SCANS SUMMED = 50
MEAN POWER = 0.289E-08
```

Prompt: PLOT?

Enter 0 if you do not wish to display a plot. If this option is selected, the following values will be displayed on the screen: period, probability, and power. For example:

```
15.02    0.8E-02    4.85
14.98    0.6E-02    5.18
.
.
.
FORTRAN STOP
$
```

If you would like to display a plot of the data produced by this program, enter any number. Plot values for the x axis (frequency) and y axis (power) will be displayed. For example,

```
XMIN,XMAX,TICX,SSTART,+NPLT*DT= 0.0000000E+00  1.227185  0.1227186
0.0000000E+00  1.227185
YMIN,YMAX,TICY= 0.0000000E+00  7.627485  0.7627485
INPUT NEW XMIN,XMAX,TICX, IF DESIRED
```

If you are satisfied with the existing values, enter: ,,,, <CR>. Or, enter new minimum, maximum, and intensity values for the x axis. For example,

Type: ,1.25,.25 <CR>

Prompt: INPUT YMIN,YMAX,TICY, IF DESIRED

If you are satisfied with the existing values, enter: ,,,, <CR>. Or, enter new minimum, maximum, and intensity values for the y axis. For example,

Type: ,8.,.8 <CR>

If you have enter new values, the new data will be displayed. For example,

XMIN,XMAY,TICX = 0.0000000E+00 1.250000 0.2500000
YMIN,YMAX,TICY = 0.0000000E+00 8.000000 0.8000000

Prompt: TYPE 1 TO RESET

If you type '1', you will be allowed to re-enter values for the plot's x and y axes.

If you type '0', the plot will be displayed on the screen. The current date and time, the input file name, and the mean value will be displayed at the top of the plot.

To print the plot, position the cursor over the 'FILE' option at the top of the screen, drag the mouse to the 'PRINT GRAPHICS' selection, and click the mouse button twice, in quick succession.

To re-enter the FFTSUM program, position the cursor to the left of the plot and click the mouse button twice, in quick succession.

Prompt: TYPE 1 TO RESET

Type '0' if you do not wish to modify the x and y axes values of the plot.

-or-

Type '1' to display the following prompts.

Prompt: INPUT NEW XMIN,XMAX,TICX, IF DESIRED

If you would like to enlarge a plot section, such as the power factor, type values accordingly. For example,

Type: .5,1.0,.1 <CR>

Prompt: INPUT YMIN,YMAX,TICY, IF DESIRED

Adjust these values, if desired. For example,

Type: 1.0,5.0,.5 <CR>

The values you have entered will be displayed on the screen. For example,

XMIN,XMAX,TICX = 0.5000000 1.000000 0.1000000
YMIN,YMAX,TICY = 1.000000 5.000000 0.5000000

Prompt: TYPE 1 TO RESET

Type: 0 <CR> to display the plot

-or-

1 <CR> to re-enter values for the x and y axes of the plot.

APPENDIX 8

APP8 - 1

STANDARD BACKGROUND

		232-285	390-410	485-500	583-588	TIME
HED1	DS1	6.075	6.07	5.968	6.042	
	2	10.775	10.76	10.643	10.812	
	3	1.655	1.63	1.551	2.182	
	4	2.275	2.27	2.167	1.182	
	SUM	20.78	20.73	20.329	20.598	
HED2	DS1		9.98	9.722	9.877	
	2		16.33	16.079	16.43	
	3		2.57	2.469	2.431	
	4		3.29	3.207	3.137	
	SUM	32.29	32.17	31.477	31.875	
MED	DS1	4.60	4.73	4.687	4.99	
	2	2.66	2.71	2.655	2.873	
	3	2.15	2.17	2.193	2.265	
	4	1.25	1.23	1.202	1.281	
	SUM	10.62	10.84	10.737	11.409	
HED3	DS1	7.155	7.13	7.024	6.744	
	2	4.415	4.41	4.305	4.139	
	3	2.02	1.97	1.906	1.833	
	4	1.68	1.64	1.570	1.517	
	SUM	15.27	15.15	14.805	14.233	

The user should choose the set of background values which are closest in time to the user's input. Add or subtract the desired discovery scalar background values according to necessity.

HRATE EXAMPLE RUN 1 -- Output

HRATE.OUT -- Lineprinter file.

```
H R A T E       VERSION OF 3/26/88
ESSENTIALLY HRATE VERSION 4/17/81
RUN AT 09:50:15 ON 20-APR-88
CHANNEL      224  RET_CODE            1
BEFORE STOP IN MOUNT_            1
OUTPUT FILE NAME: f3c273.hrt
SOURCE RA AND DEC (1950)     186.600     2.300
START TIME      END TIME
1  533  81319708   533  84975388    533.941   533.984
AKEY (1=1.28DSC,10=5.12DSC,100=MULISC)     1.00
DET   6    DSC  1  2  3  4  SCAN ANGLE LIMITS      0.000    360.000
DET   0    DSC  0  0  0  0  SCAN ANGLE LIMITS      0.000    360.000
DET   0    DSC  0  0  0  0  SCAN ANGLE LIMITS      0.000    360.000
DET   0    DSC  0  0  0  0  SCAN ANGLE LIMITS      0.000    360.000
BIT ERROR CHECK  1
ELECTRON FLAG  1
CLEAN FLAG SELECTED
JMCL=  1  1 : LE 1.2, 2 : GT 1.2, 0 ALL
OFFSET  ANGLE   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000 0 FOR AREA,1 FOR SCAN ANG 0
BACKGROUND AND ERRORS FOR POINTED DATA(CTS/S)
1        5.00000      0.50000
2        0.00000      0.00000
3        0.00000      0.00000
4        0.00000      0.00000
BACKGROUND AND ERRORS FOR POINTED DATA CTS/ 1.280 S
1        6.40000      0.64000
2        0.00000      0.00000
3        0.00000      0.00000
4        0.00000      0.00000
FLAGS FOR ELECTRONS SET AT      1000.     800.     1200.     800.
1 1  533 81343388  533.941   666.149     0.03354165
0.00697877      1
2 1  533 81368988  533.942   668.032     0.02292181
0.00600999      1
3 3  533 81384348  533.942   669.933     0.01819211
0.00552046      1

                                  .
                                  .
                                  .
91 7    533 84932508  533.983   665.453     0.02653267
0.00636674      1
92 9    533 84947868  533.983   681.702     0.02590024
0.00621498      1
94 9    533 84973468  533.983   702.628     0.01400991
0.00489861      1
```

9.0 SURFACE BRIGHTNESS ANALYSIS

In order to create a contour plot of the brightness of an area of the X-ray sky, the user must run the following programs in order:

1) DSDISK
2) CSE
3) NICER (optional)
4) PLT2D

9.1 THE CSE PROGRAM

The CSE program converts data produced by the DSDISK program (DSDISK.TMP) into a format which is more appropriate for producing contour plots. Also, a header line is added to the data to identify the file and provide the dimensions (25 degree scan angle by "N" days of data) of the contour plot. A multiple record (6 records) DSDISK.TMP file was created using the IAUTO=1 option in response to the *ENTER TITLE (A9)* prompt of the DSDISK program.

The execution of the CSE program is straightforward and proceeds as follows:

```
$ RUN [XRAY]CSE

SKYPLT NAME? dsdisk.tmp

XMIN,XMAX=  N.NNN    N.NNN        RECORDS=  N

OUTPUT FILE NAME? source.plt

FORTRAN STOP
$
```

The output from the CSE program is in a binary file "source.plt"; this output file is the input for the NICER program.

9.2 THE NICER PROGRAM

The NICER program processes data which has been produced by the CSE program. This data is essentially a two dimensional matrix of information where the first dimension is the scan direction of 25 degrees, and the second dimension is represented by the days of data. The data represents a contour plot of Scan Degrees X Days of Data.

The NICER program acts as a filter on the data. NICER computes the mean and standard deviation (noise) of the data. The filtering is accomplished with a 5x5 boxcar smoothing function, omitting points that lie more than "N" sigma outside of the average; "N" is input by the user. The typical value for "N" is 4 or greater. This method of smoothing prevents large noise spikes from being included in the average for the data. The assumption here is that the same value of sigma applies across both background and sources; the assumption that the noise is NOT Poisson and does not increase across the source. The user should note that the program makes no corrections for variations in the counting statistics. Pixels with a small number of events can show large spikes.

The execution of the NICER program is straightforward and proceeds as follows:

$ RUN [XRAY]NICER

INPUT FILE NAME?
source.plt

Source.plt is the file that has been produced by the CSE program.

```
N=nnn        AVG=nnn        SIG=nnn        ILO=nnn        IHI=nnn
FUDGED TO    AVG=nnn        SIG=nnn
IW,I1,NBIN=     n      nnn      nn
N=nnn        AVG=nnn        SIG=nnn
WRITING OUTPUT OF UNIT 3 TO $DISK1:NICER.TMP
NTERMS,IS?
```

The user should enter a <CR> here for the standard model. The default for NTERMS is "6" and IS is "1".

Statistics and fit diagnostics will now be printed to the screen.

nn BIN HISTOGRAM FIT GIVES AVG=nnn   SIG=nnn
OUTPUT FILE?
source.nic

The user should give the output filename an extension of "nic" in order to identify that it is output from the NICER program.

*FOR N*SIGMA, WHAT IS N?*
4

This is where the user should enter a value of 4 or greater.

Histogram information appears.

COUNTS LOST nnn

There are three output files from the NICER program: NICER.TMP, MODEL.TMP and the file that the user has named (in this case "source.nic"). NICER.TMP and MODEL.TMP are ebcdic files which contain statistical information. The "source.nic" file contains the results of the NICER program in binary format which can be plotted using the PLT2D program that is described in the next section.

Examples of the output from the NICER program, MODEL.TMP and NICER.TMP, can be found in the appendix following this chapter (APP9 - 1).

9.3 THE PLT2D PROGRAM

(This section will be developed).

APPENDIX 9

NICER EXAMPLE RUN 1

NICER -- MODEL.TMP Output

```
 1  0.2178507
 2  0.5017840
 3  0.7523134
 4  0.9694390
 5   1.153161
 6   1.303478
 7   1.420392
 8   1.503902
 9   1.554008
10   1.570710
11   1.554008
12   1.503902
13   1.420392
14   1.303478
15   1.153161
16  0.9694390
17  0.7523134
18  0.5017840
19  0.2178507
20 -9.9486753E-02
21 -0.4502279
22 -0.8343732
23  -1.000000
24  -1.000000
25  -1.000000
26  -1.000000
27  -1.000000
28  -1.000000
```

NICER -- NICER.TMP Output

```
 1  0.4771213
 2  0.0000000E+00
 3  0.8450980
 4  0.8450980
 5   1.342423
 6   1.612784
 7   1.690196
 8   1.838849
 9   1.838849
10   1.903090
11   1.863323
12   1.690196
13   1.591065
14   1.518514
15   1.113943
16   1.146128
17   1.041393
18  0.6989700
19  0.4771213
20  0.3010300
21  0.0000000E+00
22  0.4771213
23  -1.000000
24  0.0000000E+00
25  0.0000000E+00
26  0.3010300
27  0.0000000E+00
28  -1.000000
```

10.0 UTILITY PROGRAMS

10.1 THE HEAORB PROGRAM

The HEAORB program reads MAX tapes (or GETSRC tapes which have the same format) and prints various data (which can be selected) on the lineprinter. The program is useful in determining the status of the experiment, or where it was pointed as a function of time. It can also be used to determine why data was rejected by other programs.

In order to use the HEAORB program, the user must first mount the MAX tape in the tapedrive. The tapedrive associated with the MicroVAX computer (GCR CacheTape 1600/3200/6250 bpi) requires the user to insert the tape horizontally into position. Open the drive cover by pressing down on the top of the plastic shield. This shield is on a hinged mechanism and will slide open. Remove the tape band, insert the tape onto the spool and close the shield. Press the "load" button and wait until the load light stops flashing. Check the tape density and change it if necessary by pressing the "density select" button. Finally, press the "online" button.

10.1.1 Discussion of the HEAORB Options

0=DEFAULT=SPECIFY SOME DET ON AND UNOCCULTED
1=DO ALL DATA
The "0" (default) option will only process data and produce output if at least one detector is on and the experiment is not occulted by the earth. This option reduces unnecessary output. Option "1" will process data and produce output for all data on the tape.

0=DEFAULT=PROCESS ALL RECORDS ON TAPE
1=LOCATE ALL OCCURRENCES OF THE TIME INTERVAL
2=STOP AFTER PROCESSING TIME INTERVAL ONCE
Option "0" (default) will process all information contained on the tape. The user will not be prompted for a time interval, nor will the Earth-Sun vector be calculated. Option "1" will process all occurrences of the input time interval. Option "2" will only process the first occurrence of the input time interval.

> If the user chose option "1" or option "2" of the previous prompt, then the next two questions will appear.
>
> *0=DEFAULT=NO OPERATION*
> *1=CALC. EARTH-SUN VECTOR*
> Option "0" (default) will bypass the computation of the earth-sun vector; option "1" will cause the earth-sun vector to be computed.
>
> *ENTER START T, END T (DAY,MSEC)*
> The times are input in the form of DDD,MMMMMMMM (e.g, 540,10800000).

TYPE N FOR NO. OF SOURCE POSITIONS (LE 6)
This prompt has to do with the effective area of the detectors. If the

value entered is greater than zero, the user will be prompted with the next question:

> *TYPE RA AND DEC IN DEGREES (SOR/LINE)*
> This prompt will be repeated "N" times, where "N" was entered as the number of source positions. Input the source coordinates (RA and DEC in decimal degrees), one source per line.

0=DEFAULT=DO NOT PRINT Y, Z RA AND DEC
1=PRINT OUT Y,Z, RA AND DEC IN RAD
2=PRINT OUT Y,Z, RA AND DEC IN DEG (Currently, does not work)
The user may choose the format of the output information.

****
PROGRAM NO LONGER ALLOWS GODDARD ASPECT SOLUTION TO BE CORRECTED USING A3 ASPECT DATA
****
This is historical information for the user. On the HEAO 1 satellite, both the satellite and the A-3 experiment obtained aspect data. It was determined that for long exposures, the satellite aspect data was unreliable. Hence, the A-2 project decided to use the aspect information from the A-3 experiment; however, it was difficult to obtain the information, and the idea was abandoned.

0=DEFAULT=NO DUMP
1=OCTAL DUMP OF DATA WORDS
The "0" (default) option will not produce an octal dump of the data. The "1" option will produce the octal dump; this option should be used only if the Error Flag #4, HERRF4, appears in the HEAORB output. Please refer to the next section (10.1.1.1) for instructions pertaining to the octal dump. In most instances, this option is not used.

All the necessary information has been input to the program at this time. The program will automatically notify the system to allocate the tapedrive and mount the user's tape.

%MOUNT-I-WRITELOCK, volume is write locked.
%MOUNT-I-MOUNTED, MOUNTED on _MSA0:

The program will read the MAX tape. The information the user has requested is written out to the disk file HEOARB.OUT in the user's directory, along with information on the electron flags, earth occult flags, PHA channel modes, and RAM/ROM numbers.

FORTRAN STOP
$

The program will automatically take the tape offline and unload the tape from the system at the completion of the program. To retrieve the tape from the tapedrive, simply open the tapedrive and remove the tape.

10.1.1.1 Octal Dump of Data Words Using the HEAORB Program

This option may be used when a previous HEAORB run has displayed an Error Flag #4, HERRF4. This message indicates that some of the data in the major frame is "fill data", which has replaced original data that was lost, perhaps in transmission. The fill data may be designated by the hexidecimal code, "AA", or by "252" in octal code in the octal dump output. The octal dump will display a major frame of data. Each major frame on the MAX and GETSRC tapes consists of 40.96 seconds of data.

The following two error messages may also appear in your HEAORB report:

Error Flag #1 (HERRF=1): This means that the error occurred while transmitting data from the satellite to the ground.

Error Flag #2 (HERRF=2): This means that the error occurred while transmitting data from the ground to the final data center.

If either of these error messages appear, the major frame of data being accessed will contain minimal, if any, useful data; the user should select another major frame of data for analysis. If only HERRF4 appears, it may mean that only a few data words have been lost.

To access the HEAORB octal dump feature, answer the prompt

0=DEFAULT=NO DUMP
1=OCTAL DUMP OF DATA WORDS

with the "1" option.

```
MAX COMMON:  IDAY,IMSEC,HFORM,HRAM,HERR4,HENG,...
             1     2     3         4
                         .
                         .
                         .
ODATA(25),HCAL(32,6),IHK(10,6),HDSC(5,8,8,6),HDATA(3840)
732       757        853       913            1873

FOR DUMP, TYPE START WORD #, END WORD #, IN 2I5
```

<u>NOTE</u>: The data element names are those which were defined in the original software used during the HEAO mission. They are used to describe hardware characteristics, such as RAMs and ROMs, start days and other mission data. For further information, refer to the following manual: *High Energy Astronomy Observatory Satellite-A FRAPPE Program Description and Operator's Guide*, Appendix B, #CSC TM-79/6321.

Enter the word (a word is 4 bytes) numbers within the array in which the error may have occurred. The numbers denote the beginning of each array. In this example, the HDATA array began at word 1873. The HDATA array ends at word 3792. For example,

NNNN,NNNN

DEBUT NSTRT, NEND NNN NNN I1, I2 NNNN NNNN

The user will be instructed to mount the data tape to the designated tape drive and the job will be run. When the octal dump of data has been analyzed, the user should be able to determine where the data loss occurred or which data were lost.

10.1.2 Two Example Runs of the HEAORB Program

Example 1

```
$ RUN [XRAY]HEAORB

*****************************************************************

LINE PRINTER OUTPUT WILL BE IN
   HEAORB.OUT

*****************************************************************

0=DEFAULT=SPECIFY SOME DET ON AND UNOCCULTED
1=DO ALL DATA
0

0=DEFAULT=PROCESS ALL RECORDS ON TAPE
1=LOCATE ALL OCCURRENCES OF THE TIME INTERVAL
2=STOP AFTER PROCESSING TIME INTERVAL ONCE
2

0=DEFAULT=NO OPERATION
1=CALC. EARTH-SUN VECTOR
1

ENTER START T, END T (DAY,MSEC)
262,88288290,262,95251490

TYPE N FOR NO. OF SOURCE POSITIONS (LE 6)
0

0=DEFAULT=DO NOT PRINT Y, Z RA AND DEC
1=PRINT OUT Y,Z, RA AND DEC IN RAD
2=PRINT OUT Y,Z, RA AND DEC IN DEG
1

*******************************************************************
PROGRAM NO LONGER ALLOWS GODDARD ASPECT SOLUTION TO BE
CORRECTED USING A3 ASPECT DATA
*******************************************************************

0=DEFAULT=NO DUMP
1=OCTAL DUMP OF DATA WORDS
0

%MOUNT-I-WRITELOCK, volume is write locked.
%MOUNT-I-MOUNTED, MOUNTED on _MSA0:

FORTRAN STOP
$
```

The output from this run of the program has been written to the user's directory. The output from this HEAORB run, Example 1, is included in the appendix (APP10 - 1) following this chapter.

Example 2 -- Octal Dump

```
$ RUN [XRAY]HEAORB

*******************************************************************

LINE PRINTER OUTPUT WILL BE IN
   HEAORB.OUT

*******************************************************************

0=DEFAULT=SPECIFY SOME DET ON AND UNOCCULTED
1=DO ALL DATA
0

0=DEFAULT=PROCESS ALL RECORDS ON TAPE
1=LOCATE ALL OCCURRENCES OF THE TIME INTERVAL
2=STOP AFTER PROCESSING TIME INTERVAL ONCE
2

0=DEFAULT=NO OPERATION
1=CALC. EARTH-SUN VECTOR
1

ENTER START T, END T (DAY,MSEC)
262,88288290,262,95251490

TYPE N FOR NO. OF SOURCE POSITIONS (LE 6)
0

0=DEFAULT=DO NOT PRINT Y, Z RA AND DEC
1=PRINT OUT Y,Z, RA AND DEC IN RAD
2=PRINT OUT Y,Z, RA AND DEC IN DEG
1

**********************************************************************
PROGRAM NO LONGER ALLOWS GODDARD ASPECT SOLUTION TO BE
CORRECTED USING A3 ASPECT DATA
**********************************************************************

0=DEFAULT=NO DUMP
1=OCTAL DUMP OF DATA WORDS
1

MAX COMMON:  IDAY,IMSEC,HFORM,HRAM,HERR4,HENG,...
             1    2     3          4
                        .
                        .
                        .
ODATA(25),HCAL(32,6),IHK(10,6),HDSC(5,8,8,6),HDATA(3840)
732       757        853       913           1873

FOR DUMP, TYPE START WORD #, END WORD #, IN 2I5
```

```
1873,3792

DEBUG NSTRT, NEND 1873 3792 I1, I2 7489 15168

%MOUNT-I-WRITELOCK, volume is write locked.
%MOUNT-I-MOUNTED, MOUNTED on _MSA0:

FORTRAN STOP
$
```

The output from this run of the program has been written to the user's directory. The output from this HEAORB run, Example 2 -- Octal Dump, is included in the appendix (APP10 - 2) following this chapter.

10.2 THE SOURCE PROGRAM

The SOURCE program is used to perform coordinate transformations and to determine when a particular source was in the field of view of the A-2 experiment.

```
$ RUN [XRAY]SOURCE
```

SOURCE PROGRAM VRS 07-JAN-88

"LINE PRINTER" OUTPUT IS IN "SOURCE.OUT"
ENTER 1 TO JUST TRANSFORM COORDINATES
DEFAULT TO TRANSFORM AND SHOW HEAO A-2 VISIBILITY.

Enter "0" (default) to perform both the coordinate transformation and to obtain a list of days that a source was in the field of view of the experiment. Enter "1" to perform only the coordinate transformation.

ENTER THE NUMBER WHICH CORRESPONDS TO THE
TYPE OF POSITION YOU HAVE FOR THE OBJECT

```
0     RA IN HRS MINS SECS     DEC IN DEG MIN SEC  50
1     RA IN HRS MINS SECS     DEC IN DEGREES      1950
2     RA IN HRS MINS SECS     DEC IN DEGREES      1977.5
3     RA IN DEGREES           DEC IN DEGREES      1950
4     RA IN DEGREES           DEC IN DEGREES      1977.5
5     L(II) IN DEGREES        B(II)IN DEGREES
6     EC.LNG IN DEGREES       EC.LAT IN DEGREES
7     TIME(YR,DOY,HR,MIN,SC)  SCAN ANGLE IN DEGREES
 ENTER ^Z TO STOP
```

Select the numbered option which corresponds to the input data.

TYPE IN POSITION, FORMAT XXXXXXXXXXX

Enter the RA (right ascension) and DEC (declination) coordinates in the specified format. The specific format for the data input is dependent upon the type of position coordinates that the user claimed for the source object. The user should adhere to the "integer" or "real" format of the specific input request, separating the coordinates by commas. For example,

```
213.72,19.75              (for choice 3 above)
14,15,3.2,19,15,0.0       (for choice 0 above)
```

The program will display the object's position in all of the coordinate systems on the terminal. Then, for each day that the source was in the field of view of the A-2 detectors, the program displays the day of year, the degrees off center, and the scan angle. This information is also written to the disk file "SOURCE.OUT". The program will now request more input data. To exit, enter ^Z.

10.2.1 Two Example Runs of the Source Program

Example 1

```
$ RUN [XRAY]SOURCE

SOURCE PROGRAM VRS 07-JAN-88

"LINE PRINTER" OUTPUT IS IN "SOURCE.OUT"
ENTER 1 TO JUST TRANSFORM COORDINATES
DEFAULT TO TRANSFORM AND SHOW HEAO A-2 VISIBILITY.
0

            ENTER THE NUMBER WHICH CORRESPONDS TO THE
            TYPE OF POSITION YOU HAVE FOR THE OBJECT

      0     RA IN HRS MINS SECS    DEC IN DEG MIN SEC  50
      1     RA IN HRS MINS SECS    DEC IN DEGREES      1950
      2     RA IN HRS MINS SECS    DEC IN DEGREES      1977.5
      3     RA IN DEGREES          DEC IN DEGREES      1950
      4     RA IN DEGREES          DEC IN DEGREES      1977.5
      5     L(II) IN DEGREES       B(II)IN DEGREES
      6     EC.LNG IN DEGREES      EC.LAT IN DEGREES
      7     TIME(YR,DOY,HR,MIN,SC) SCAN ANGLE IN DEGREES
       ENTER ^Z TO STOP
0

TYPE IN POSITION, FORMAT I2,I2,F4.1,I3,I2,F4.1
14,15,0.0,19,15,0.0
```

The coordinate transformation will now be displayed as well as the days that the source was in the experiment field of view.

```
            ENTER THE NUMBER WHICH CORRESPONDS TO THE
            TYPE OF POSITION YOU HAVE FOR THE OBJECT.
                .
                .
                .
       ENTER ^Z TO STOP
^Z
EXIT
FORTRAN STOP
$
```

The coordinate transformation information and the days of HEAO A-2 visibility have been written to the output file "SOURCE.OUT". The output from this SOURCE run, Example 1, is included in the appendix (APP10 - 3) following this chapter.

Example 2

```
$ RUN [XRAY]SOURCE

SOURCE PROGRAM VRS 07-JAN-88

"LINE PRINTER" OUTPUT IS IN "SOURCE.OUT"
ENTER 1 TO JUST TRANSFORM COORDINATES
DEFAULT TO TRANSFORM AND SHOW HEAO A-2 VISIBILITY.
1

            ENTER THE NUMBER WHICH CORRESPONDS TO THE
            TYPE OF POSITION YOU HAVE FOR THE OBJECT

      0     RA IN HRS MINS SECS    DEC IN DEG MIN SEC  50
      1     RA IN HRS MINS SECS    DEC IN DEGREES     1950
      2     RA IN HRS MINS SECS    DEC IN DEGREES     1977.5
      3     RA IN DEGREES          DEC IN DEGREES     1950
      4     RA IN DEGREES          DEC IN DEGREES     1977.5
      5     L(II) IN DEGREES       B(II)IN DEGREES
      6     EC.LNG IN DEGREES      EC.LAT IN DEGREES
      7     TIME(YR,DOY,HR,MIN,SC) SCAN ANGLE IN DEGREES
       ENTER ^Z TO STOP
3

TYPE IN POSITION, FORMAT F8.0 F7.0
213.72,19.75
```

The program will now display the coordinate transformation information.

```
            ENTER THE NUMBER WHICH CORRESPONDS TO THE
            TYPE OF POSITION YOU HAVE FOR THE OBJECT.
                 .
                 .
                 .
       ENTER ^Z TO STOP
^Z
EXIT
FORTRAN STOP
$
```

The coordinate transformation information has been written to the output file "SOURCE.OUT". The output from this SOURCE run, Example 2, is included in the appendix (APP10 - 4) following this chapter.

10.3 THE ERRBOX PROGRAM

The ERRBOX program allows the user to display on the terminal screen error boxes and source positions on a rectangular grid (presumed to be RA and DEC).

$ RUN [XRAY]ERRBOX

```
PROGRAM ERRBOX 01-JAN-88 VRS.
INPUT IS FROM A USER-SPECIFIED DISK FILE.
THERE IS NO "LINE-PRINTER" OUTPUT.
RECORD 1:RA-MIN,RA-MAX, NO. OF TICS ON AXIS.
RECORD 2:DEC-MIN,DEC-MAX, NO. OF TICS
RECORDS 3-N: RA,DEC,IPEN
      IPEN=0 PEN DOWN--DRAW A LINE
      IPEN=1 PEN UP--JUST MOVE PEN
      IPEN=2 PLOT *
      IPEN=3 CONNECT TO PREVIOUS IPEN=1

ENTER INPUT FILE NAME (48A1) or ^Z TO QUIT
```

The first two lines of input to the program determine the coordinate grid. The remaining inputs are plotting commands with the format:

RA(x-value),DEC(y-value),IPEN(pen command number)

IPEN of "0" draws a line from the previous pen position to the current RA and DEC position. IPEN of "1" moves the pen to the current position without drawing a line. IPEN of "2" plots the "*" symbol at the current position. IPEN of "3" draws a line to the previous IPEN=1 position from the current position.

If a file name is entered, the ERRBOX program will read this file and draw the data onto the terminal screen. The user will be prompted by the plot package for the specific terminal type in use:

```
POSSIBLE GRAPHICS DEVICES:
P -- PRINTRONIX        V -- VERSATEC       L -- LIACOM
T -- TEKTRONIX         5 -- VT152          Z -- ZETA
A -- ARGS              G -- GRINNELL       N -- NULL
SELECT GRAPHICS DEVICE FOR CURRENT PLOT: T
WHICH TEKTRONIX TERMINAL IS FREE? <CR>
```

The user should choose the Tektronix type terminal (T) and enter a <CR> to the *WHICH TEKTRONIX TERMINAL IS FREE?* question. Once the drawing has been completed, the following prompt will be displayed:

```
ENTER TITLE 60A1
MYPLOT
```

The title will be printed at the top of the drawing.

```
HIT RETURN TO CONTINUE
```

```
\ENTER INPUT FILE NAME (48A1) or ^Z TO QUIT
^Z
EXIT
FORTRAN STOP
$
```

The only output generated by the ERRBOX program is a plot to the user's terminal screen; no output disk files are created.

10.3.1 Sample Input File for the ERRBOX Program

See Section 3.2.3 for instructions on how to create a disk file. Specifically, follow these guidelines to create an input file for the ERRBOX program.

```
            Disk File Input

Line 1:     204.0,199.0,20
Line 2:     9.0,14.0,20
Line 3:     201.521,12.014,2
Line 4:     199.60,12.28,1
Line 5:     199.80,12.74,0
Line 6:     203.18,11.33,0
Line 7:     202.98,10.87,0
Line 8:     0.0,0.0,3
Line 9:     202.96,10.91,1
Line 10:    201.08,11.69,0
Line 11:    201.16,11.86,0
Line 12:    203.04,11.08,0
Line 13:    0.0,0.0,3
Line 14:    202.04,12.0,1
Line 15:    201.5,12.5,0
Line 16:    201.25,12.0,0
Line 17:    201.75,11.5,0
Line 18:    0.0,0.0,3
```

The RA and DEC coordinates are input as "real"; tic mark divisions and IPEN values are input as "integer".

Line 1: The RA minimum and the RA maximum (horizontal axis), and the number of tic marks which divide the axis into equal sections.

Line 2: The DEC minimum and DEC maximum (vertical axis), and the number of tic marks which divide the axis into equal sections.

Information from Lines 1 and 2 configure the x and y axes grid.

The remaining input lines (Lines 3-18) denote RA, DEC, and IPEN. The RA and DEC tell the plotter where to position the pen, and IPEN gives the specific pen commands to the screen.

IPEN=0 : Pen down and draw a line from the previous pen position to the current pen postion. (the default value)

IPEN=1 : Pen up and move the pen from the previous pen position to the current pen position.

IPEN=2 : Plot the "*" symbol at the current RA and DEC position.

IPEN=3 : Pen down and draw a line from the current pen position to the previous IPEN=1 position. This is used to close a box.

Line 3: Position the pen at a given location and draw a "*".

Lines 4-8: Draw a box.

Lines 9-13: Draw a box.

Lines 14-18: Draw a box.

HEAORB EXAMPLE RUN 1

```
HEAORB      VERSION OF 1/12/88
RUN AT 15:16:44 ON 11-FEB-88
START T - END T   262D  8828829MS  262D 9525149MS  262.1022 262.1103
CHANNEL      224  RET_CODE              1
BEFORE STOP IN MOUNT.            1
FLAGS FOR ELECTRONS SET AT       1000.       800.      1200.      800.
TIME=   262  8828829 262.102 MODE=  3 RAM=  1   PHA MODE= 32 32 32 32
 32 32
ORB NO.=         585 #ELEC=       271.      1215.       881.       74.
OK,OCCULT=      T  F F F F    T  F F F F    T  F F F F    T  F F F F
Y DIR MID MF  266.160 -15.171 HED1 DIR  265.988 -21.169
SCAN ANGLES: START    4.456   358.456 END   12.232      6.232
E-SAT KM:    5934.24  -3300.21     449.42 D E-SAT:    6805.04 E-SUN: -0.99
762726  0.06316376  0.02738719 D E-SUN:  0.99999992
YRA,YDEC,ZRA,ZDEC IN RADIANS
    4.6421  -0.3304          3.0807   0.0274
    4.6431  -0.3129          3.0811   0.0269
    4.6442  -0.2954          3.0815   0.0265
    4.6450  -0.2779          3.0816   0.0261
    4.6455  -0.2604          3.0816   0.0257
    4.6460  -0.2429          3.0815   0.0254
    4.6465  -0.2254          3.0814   0.0251
    4.6470  -0.2079          3.0814   0.0248
TIME=    262  8869789 262.103 MODE=  3 RAM=  1   PHA MODE= 32 32 32 32
32 32
ORB NO.=         585 #ELEC=       326.       934.      1129.      191.
OK,OCCULT=      T  F F F F    T  F F F F    T  F F F F    T  F F F F
Y DIR MID MF  266.383  -7.155 HED1 DIR  266.239 -13.153
SCAN ANGLES: START   12.483     6.483 END   20.247     14.247
E-SAT KM:    6061.23  -3039.18     568.54 D E-SAT:    6804.30 E-SUN: -0.99
762779  0.06315637  0.02738399 D E-SUN:  0.99999990
YRA,YDEC,ZRA,ZDEC IN RADIANS
    4.6475  -0.1904          3.0814   0.0245
    4.6479  -0.1729          3.0814   0.0242
    4.6484  -0.1555          3.0814   0.0238
    4.6489  -0.1380          3.0814   0.0235
    4.6494  -0.1205          3.0814   0.0232
    4.6499  -0.1030          3.0814   0.0228
    4.6503  -0.0856          3.0815   0.0225
    4.6508  -0.0681          3.0815   0.0222
TIME=    262  8910749 262.103 MODE=  3 RAM=  1   PHA MODE= 32 32 32 32
32 32
ORB NO.=         585 #ELEC=       124.      1038.       990.       35.
OK,OCCULT=      T  F F F F    T  F F F F    T  F F F F    T  F F F F
Y DIR MID MF  266.593   0.853 HED1 DIR  266.459  -5.145
SCAN ANGLES: START   20.498    14.498 END   28.254     22.254
E-SAT KM:    6174.00  -2771.22     686.26 D E-SAT:    6802.13 E-SUN: -0.99
762839  0.06314898  0.02738078 D E-SUN:  0.99999994
```

```
YRA,YDEC,ZRA,ZDEC IN RADIANS
    4.6513  -0.0506          3.0816   0.0219
    4.6517  -0.0331          3.0817   0.0218
    4.6522  -0.0157          3.0817   0.0220
    4.6526   0.0018          3.0818   0.0222
    4.6530   0.0193          3.0818   0.0223
    4.6535   0.0367          3.0819   0.0225
    4.6540   0.0542          3.0819   0.0226
    4.6544   0.0716          3.0820   0.0228
TIME=    262  9525149 262.110 MODE=  3 RAM=  1   PHA MODE= 32 32 32 32
32 32
ORB NO.=        585 #ELEC=        87.       909.       901.       127.
OK,OCCULT=       T  F F F F    T  F F F F    T  F F F F    T  F F F F
Y DIR MID MF   82.865  60.837 HED1 DIR   81.786  66.818
SCAN ANGLES: START  138.878   132.878 END  146.349   140.349
E-SAT KM:    6247.14   1604.25   2148.98 D E-SAT:   6798.42 E-SUN: -0.99
763668  0.06303799  0.02733267 D E-SUN:  0.99999991
YRA,YDEC,ZRA,ZDEC IN RADIANS
    1.4356   1.1248          3.0796   0.0350
    1.4387   1.1080          3.0795   0.0349
    1.4416   1.0912          3.0794   0.0348
    1.4444   1.0744          3.0792   0.0347
    1.4469   1.0576          3.0791   0.0346
    1.4493   1.0408          3.0790   0.0345
    1.4515   1.0241          3.0789   0.0344
    1.4536   1.0073          3.0787   0.0343
END OF FILE         -10       15168 FILE NO.   1
NO. OF RECORDS WITH NE<0: HED1,HED2,MED,HED3     18      0      0     12
DISTRIBUTION OF NO. OF ELECTRONS
NUMBER        HED1    HED2    MED    HED3
0-  99         26       1      5      38
100- 199       26       6      6      35
200- 299       25       4      4      27
300- 399       12       6     10      15
400- 499        8       9      7      14
500- 599        7       7      9      11
600- 699        9      12      9       4
700- 799        6      10     14       1
800- 899        6       7      8       5
900- 999        6      17     14       5
1000-1099       2      15      9       2
1100-1199       5       6     12       2
1200-1299       3      11      7       1
1300-1399       3       7      5       1
1400-1499       0       4      8       1
1500-1599       1       6      2       4
1600-1699       1       4      4       1
1700-1799       1       7      8       2
1800-1899       1       4      2       1
1900-1999       1       2      4       3
2000-2099       2       4      5       0
2100-2199       5       4      3       0
```

APP10 - 1 continued

2200-2299	2	5	4	0
2300-2399	0	2	2	1
2400-2499	0	0	0	0
2500-2599	3	6	2	0
2600-2699	0	1	3	0
2700-2799	1	2	4	0
2800-2899	3	0	2	1
>2899	8	22	19	4

SOURCE IN FIELD OF VIEW

0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0

HEAORB EXAMPLE RUN 2 -- Octal Dump

```
HEAORB       VERSION OF 1/12/88
RUN AT 15:25:32 ON 11-FEB-88
START T - END T   262D  8828829MS  262D  9525149MS  262.1022 262.1103
MAX COMMON: IDAY,IMSEC,HFORM,HRAM,HERRF,HENG,
              1     2     3 .     4
HOCC1,HOCC2,HELEC,HMAG,HHV,HSAA,HJET,HHVST,HSPARE(8),
5           6          7          8           9
IMICRO(2 ),HMFCNT,QCSTAT(6),QDSTAT(64),QASTAT(32),
13         15         16       17          33
QDFOR(128),QERR1(128),QERR2(128),ICLOCK(128),
41           73          105          137
SPRA(32),SPDEC(32),YRA(32),YDEC(32),SPLON(32),
265        297         329       361       393
SPLAT(32),YLON(32),YLAT(32),GYRO(32,3),ZERR(32),
425         457        489        521          617
YERR(32),ATT(32),HBUS(4),HEAA2,HA2STB,HT1,HT2,
649        681       713       715           716
QUAT(24),B(3),PHIEAR,THEAR,E1,E2,ITYPE,IONUM,
717        723  726     727  728,729 730  731
ODATA(25),HCAL(32,6),IHK(10,6),HDSC(5,8,8,6),HDATA(3840)
732         757          853         913            1873
DEBUG NSTRT, NEND  1873 3792 I1, I2   7489 15168
CHANNEL      224  RET_CODE              1
BEFORE STOP IN MOUNT.              1
OCTAL DUMP OF MAJOR FRAME WORDS 1873 TO 3792
2  0   7  0   1  0  1  0   3 .... 0  6   0  3  0  5   0  5  0  0   5  0
3  0   1  0   7  0  3  0   4 .... 5  0   5  0  3  0   1  0  4  0   4  0
3  0   4  0   3  0  3  0   2 .... 3  0   2  0 11  0   4  0  3  0   1  0
                                  .
                                  .
                                  .
1  0   6  0   2  0  1  0   2 .... 2  0   2  0  3  0   1  0  3  0   2  0
2  0   1  0   3  0  4  0   1 .... 4  0   1  0  6  0   1  0  1  0   4  0
2  0   4  0   3  0  4  0   2 .... 2  0   2  0  4  0   2  0  3  0   1  0
TIME=    262   9525149 262.110 MODE=  3 RAM=  1   PHA MODE= 32 32 32 32
 32 32
ORB NO.=         585 #ELEC=        87.        909.        901.       127.
OK,OCCULT=       T  F F F F    T  F F F F    T  F F F F    T  F F F F
Y DIR MID MF   82.865  60.837 HED1 DIR   81.786  66.818
SCAN ANGLES: START  138.878   132.878 END  146.349    140.349
E-SAT KM:    6247.14   1604.25   2148.98 D E-SAT:   6798.42 E-SUN: -0.99
763668  0.06303799  0.02733267 D E-SUN:  0.99999991
YRA,YDEC,ZRA,ZDEC IN RADIANS
    1.4356   1.1248        3.0796   0.0350
    1.4387   1.1080        3.0795   0.0349
    1.4416   1.0912        3.0794   0.0348
    1.4444   1.0744        3.0792   0.0347
    1.4469   1.0576        3.0791   0.0346
    1.4493   1.0408        3.0790   0.0345
    1.4515   1.0241        3.0789   0.0344
    1.4536   1.0073        3.0787   0.0343
```

NO. OF RECORDS WITH NE<0: HED1,HED2,MED,HED3 0 0 0 0

DISTRIBUTION OF NO. OF ELECTRONS

NUMBER	HED1	HED2	MED	HED3
0- 99	1	0	0	2
100- 199	1	0	0	2
200- 299	1	0	0	0
300- 399	1	0	0	0
400- 499	0	0	0	0
500- 599	0	0	0	0
600- 699	0	0	0	0
700- 799	0	0	0	0
800- 899	0	0	1	0
900- 999	0	2	2	0
1000-1099	0	1	0	0
1100-1199	0	0	1	0
1200-1299	0	1	0	0
1300-1399	0	0	0	0
1400-1499	0	0	0	0
1500-1599	0	0	0	0
1600-1699	0	0	0	0
1700-1799	0	0	0	0
1800-1899	0	0	0	0
1900-1999	0	0	0	0
2000-2099	0	0	0	0
2100-2199	0	0	0	0
2200-2299	0	0	0	0
2300-2399	0	0	0	0
2400-2499	0	0	0	0
2500-2599	0	0	0	0
2600-2699	0	0	0	0
2700-2799	0	0	0	0
2800-2899	0	0	0	0
>2899	0	0	0	0

SOURCE IN FIELD OF VIEW

0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0
0 0	0 0	0 0	0 0

SOURCE EXAMPLE RUN 1 -- Output

SOURCE.OUT -- Output lineprinter file.

```
SOURCE PROGRAM VRS 07-JAN-88
         RA      DEC      1950        14 15  0.0    19 15  0.0
         RA      DEC      1950          213.750     19.250
         RA      DEC      1977.5        214.072     19.123
         L(II)   B(II)    1950           15.134     68.682
         EC.LNG  EL.LAT   1977.5        204.418     30.739
```

DAY OF YEAR	DEG OFF CENTER	SCAN ANGLE
377	2.568	149.226
378	1.692	149.246
379	0.817	149.257
380	-0.059	149.261
381	-0.934	149.256
382	-1.809	149.244
383	-2.684	149.223
560	-2.748	30.779
561	-1.929	30.759
562	-1.109	30.746
563	-0.289	30.740
564	0.531	30.741
565	1.351	30.749
566	2.171	30.764
567	2.991	30.786

SOURCE EXAMPLE RUN 2 -- Output

SOURCE.OUT -- Output lineprinter file.

```
SOURCE PROGRAM VRS 07-JAN-88
        RA       DEC      1950         14 14 52.8     19 45  0.0
        RA       DEC      1950            213.720     19.750
        RA       DEC      1977.5          214.042     19.623
        L(II)    B(II)    1950             16.343     68.926
        EC.LNG   EL.LAT   1977.5          204.163     31.190
```

11.0 REFERENCE DOCUMENTS

Computer Manuals

Introduction to the MicroVAX II, Mary Ann Esfandiari, Data Management and Programming Office, Code 664, 24 February 1987.

Quick Reference Instructions to the MicroVAX VMS System, Michele De La Pena, Science Applications Research, Code 664.1, 18 December 1987.

DEC MicroVMS System Manuals.

Computer Lists and Published Papers

Point Status Book.

Tape List.

HEAO A2 Catalogue of Pre-HEAO X-Ray Sources, Frank Marshall et al., NASA/GSFC. (The Blue Book)

The HEAO 1 A-2 Experiment: The Configuration of the Hard X-Ray Detectors, by Dr. Frank E. Marshall, September 19, 1983.

The Cosmic X-Ray Experiment Aboard the HEAO A-1, by R. Rothschild, et al., Space Science Instrumentation 4 (1979), 269, 0377-7936/79/0044-0269.

Observations of the Transient X-Ray Source 4U 0115468, by L.A. Rose, et al.

New Hard X-Ray Sources Observed with HEAO A-2, F. E. Marshall et al., Ap.J. Supp. 40, 657, 1979.

A Complete X-Ray Sample of the High Latitude Sky from HEAO 1 A-2, G. Piccinotti et al., Ap.J. 253, 485, 1982.

The Absence of Rapid X-Ray Variability in Active Galaxies, Allyn F. Tennant and R. F. Mushotzky, Ap.J. 264, 92, 1983.

The HEAO A2 Survey of Abell Clusters and the X-Ray Luminosity Function, J. D. McKee et al., Ap.J. 242, 857, 1980.

Detailed Documentation of the Data Processing System

High Energy Astronomy Observatory Satellite-A (HEAO-A2) Data Processing System, #CSC/TM-83/6148, September, 1983.

Specific manuals (written by CSC) describing in detail the programs used to process the HEAO A-2 data.

12.0 USEFUL BACKGROUND INFORMATION

12.1 ASPECT SOLUTION

During rare intervals of the mission, the aspect determined for the spacecraft was either unreliable or had large uncertainties. These periods are not rejected by standard A-2 software, and the information to find such times exists only on the MAX tapes. Hence, the inclusion of these times in the analysis can lead to anomalous results. Times of bad aspect solutions occurred on DOYs 323, 504, 623, and 643. A complete list of times is stored in a file accessed by the IBM 3081 computer.

The data file "XRHKR.ASPECT.DATA(ASPECT)" contains a complete list of all times when the estimated error in either the satellite y-axis (detector axis) or z-axis (spin axis) was greater than approximately 0.05 degrees. The errors range from a few hundredths of a degree (typical) to several degrees (atypical). It may be necessary to determine this particular error for the data in question if one is looking for variability on timescales less than or equal to one satellite orbit (90 minutes). The file lists time in Days of 1977 and milliseconds, and the spacecraft axes in radians for each major frame that has a large position error. The estimated errors are the sum of all 32 (every 1.28 seconds) error estimates within the major frame. The information contained in the file is described as follows:

mfday = day of major frame (days of 1977)
msec = milliseconds at the start of the major frame
hvflag = high voltage flag
hsanpf = SAA/NPA anomaly flag (also sunlight flag)
spra = RA of spin axis (radians, 1950 coordinates)
spdec = DEC of spin axis (radians, 1950 coordinates)
yra = RA of y-axis (radians, 1950 coordinates)
ydec = DEC of y-axis (radians, 1950 coordinates)
zertot = sum of the error for the spin axis (z-axis) (radians)
yertot = sum of the error for the y-axis (radians)

12.2 LOW VOLTAGE ON/OFF

The file "XRHKR.LVONOFF.DATA(LVONOFF)" contains a list of all times when the low voltage on each of the six A-2 detectors was turned on or off. This is a way to check which instruments were on (especially the LEDs) during a time of interest. The information contained in the file is described as follows:

mfday = day of major frame (days of 1977)
msec = milliseconds at the start of the major frame
detlv(6) = low voltage on/off words for the six (LED1, LED2, HED1, HED2, MED, and HED3) detectors

12.3 DETECTOR DIGITAL STATUS REPORT

This information is stored on tapes accessed through the use of the IBM 3081 computer. It is an "on-line" version of the Point Status Book as well as some additional information. (The Point Status Book is a computer printout that is available in the user's room.) The information includes: the RAM mode, Point Status, High Voltage Step, definition of discovery scalars 5, 6, 7 and 8, multiscalar definition, PHA mode flags, PHALIM, PHA windows, C27 and DT mode. This file can be accessed in order to determine which PHA or discovery scalar mode was being used during a particular observation time.

The Digital Status Report file is stored on the tape (HKR02) in the IBM tape library. Please see Hwa-Ja Rhee about extracting information from this tape. The information contained in the extracted output file is described as follows:

ndet	=	detector number
mfday	=	day of major frame (days of 1977)
msec	=	milliseconds at the start of the major frame
dromf(6)	=	ROM/RAM flag for the 6 A-2 detectors (LED1, LED2, HED1, HED2, MED, and HED3)
dflag(10,6)	=	10 status flags for each of the 6 detectors

The flags are described as follows:

hv power	=	high voltage power on or off
hv step	=	high voltage step
pha msb	=	PHA mode flag - most significant bit
pha lim	=	
pha w1	=	PHA window - W1
pha w2	=	PHA window - W2
ds 5,6	=	discovery scalar 5,6
ds 7,8	=	discovery scalar 7,8
ds msb	=	discovery scalar - most significant bit
delta t	=	DT mode

The HKR02 tape contains 129 files; each file contains approximately four days of data. The following list describes the time period of data for each file on the tape.

HKR02

File	Days	File	Days	File	Days
1	226 - 230	44	398 - 402	87	570 - 574
2	230 - 234	45	402 - 406	88	574 - 578
3	234 - 238	46	406 - 410	89	578 - 582
4	238 - 242	47	410 - 414	90	582 - 586
5	242 - 246	48	414 - 418	91	586 - 590
6	246 - 250	49	418 - 422	92	590 - 594
7	250 - 254	50	422 - 426	93	594 - 598
8	254 - 258	51	426 - 430	94	598 - 602
9	257 - 262	52	430 - 434	95	602 - 606 **
10	262 - 266	53	434 - 437 *	96	606 - 610
11	266 - 270	54	438 - 442	97	610 - 614
12	270 - 274	55	442 - 446	98	614 - 618
13	274 - 278	56	446 - 450	99	618 - 622 **

14	278 - 282	57	450 - 454	100	622 - 626
15	282 - 286	58	454 - 458	101	626 - 630
16	286 - 290	59	458 - 462	102	630 - 634
17	290 - 294	60	462 - 466	103	634 - 638
18	294 - 298	61	466 - 470	104	638 - 642 **
19	298 - 302	62	470 - 474	105	642 - 646
20	302 - 306	63	474 - 478	106	646 - 650
21	306 - 310	64	478 - 482	107	650 - 654
22	310 - 314	65	482 - 486	108	654 - 658
23	314 - 318	66	486 - 490	109	658 - 662
24	318 - 322	67	490 - 494	110	662 - 666
25	322 - 326	68	494 - 498	111	666 - 670
26	326 - 330	69	498 - 502	112	670 - 674
27	330 - 334	70	502 - 506	113	674 - 678
28	334 - 338	71	506 - 510 **	114	678 - 682
29	338 - 342	72	510 - 514	115	682 - 686
30	342 - 346	73	514 - 518	116	686 - 690
31	346 - 350	74	518 - 522	117	690 - 694
32	350 - 354	75	522 - 526	118	694 - 698
33	354 - 358	76	526 - 530	119	698 - 702
34	358 - 362	77	530 - 534	120	702 - 706
35	362 - 365 *	78	534 - 538	121	706 - 710
36	366 - 370	79	538 - 542	122	710 - 714
37	370 - 374	80	542 - 546	123	714 - 718
38	374 - 378	81	546 - 550	124	718 - 722
39	378 - 382	82	550 - 554	125	722 - 726 **
40	382 - 386	83	554 - 558	126	726 - 730
41	386 - 390	84	558 - 562	127	730 - 734
42	390 - 394	85	562 - 566	128	734 - 738
43	394 - 398	86	566 - 570	129	738 - 742

* == The ending day has a full day of data. An ending day without a "*" has only approximately 2 hours of data from that day.

** == The input tape has I/O errors. The processing ended before the end of the tape was reached.

ASC # 773

CSC/TM-79/6231

77-075A-02N

HIGH ENERGY ASTRONOMY OBSERVATORY SATELLITE-A (HEAO-A2) FRAPPE PROGRAM DESCRIPTION AND OPERATOR'S GUIDE

Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-24350
Task Assignment 595

Prepared by:

A. K. Tolbert 9/6/79

A. K. Tolbert — Date

Approved by:

A. R. Stottlemyer 20 Sept 79

A. R. Stottlemyer — Date
Section Manager

R. F. Williams 9/25/79

R. F. Williams — Date
Department Manager

ABSTRACT

The Cosmic X-ray experiment (A2) on board the first High Energy Astronomy Observatory (HEAO-1) satellite is designed to survey the emission of non-solar X-rays over the entire sky. The HEAO-A2 data processing system provides computerized analysis and bulk processing for this experiment at Goddard Space Flight Center (GSFC). The FRAPPE program generates the main data base for this system, reblocking and reformatting telemetry data and calculating some basic data quality flags. This document is a description of the program software and operating procedures. Detailed software documentation is present in code as it exists on the system at GSFC.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1 - INTRODUCTION

The first High Energy Astronomy Observatory (HEAO-1) satellite was launched in August 1977 with the mission of surveying the full sky for non-solar X-ray emission over a wide range of X-ray energies. The A-2 experiment consists of six detectors which, between them, cover a range in X-ray energy from 0.25 KeV to 60 KeV, and is designed to provide systematics free energy spectrum data for point and extended sources of X-rays. The experiment is mounted so as to observe the sky in a direction perpendicular to the satellite spin axis. With this orientation, each detector scans a 3-degree wide great circle of the sky each thirty minutes, and, as the spin axis precesses to point at the sun, observes the full sky over a period of 6 months.

The six detectors consist of two Low Energy Detectors (LEDs), one Medium Energy Detector (MED), and three High Energy Detectors (HEDs). Each detector observes two co-axial fields of view separately, one collimated to 3^o by 3^o (FWHM) and the other either 3^o by $1\ 1/2^o$ or 3^o by 6^o. Each field of view is observed by a multi-wire gas proportional chamber with separate outputs for each field of view in two layers of anodes, and also for exterior layers of anodes which are used to discriminate against charged particles. The data output from each detector consists of the following types: engineering analog parameters (analog status), digital experiment parameters (digital status), raw anode counting rates (Housekeeping scalers), standard coincidence counting rates (Discovery scalers), pulse height analyzed rates (PHA histograms), calibration pulse height analyzed events (Calibration data), and a type with a variety of counting rate versus time output modes (Delta-t computer).

Program FRAPPE is the generator for the primary HEAO-A2 data base (MAX), for both quicklook and production data. Using the experiment data tapes produced by the Information Processing Division (IPD) at Goddard Space Flight Center (GSFC), the program combines experiment data, selected spacecraft data, orbit data and attitude data for a given 40.96 second period (one Major

Frame) into a single physical and logical record on the data base. During this processing, several data quality tests are made and flags set to indicate the results. Additionally, the experiment telemetry is processed into a format which greatly improves the accessibility by putting all data into the form of simple integers.

The MAX data base is maintained on magnetic tape, available for use by downstream production programs, and also by experimenter analysis programs. The quicklook and production data bases are separately maintained, along with easily accessed data base catalogs. Data need not be added to the data base in strict sequential order, though the production data base is ultimately placed in sequential order for use by some of the downstream production programs.

SECTION 2 - OVERVIEW

2.1 SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules to perform separate tasks for quality control, establishing data bases for more convenient and efficient analysis, and performing some preliminary analysis of the data. The system is designed to perform both as a "Quicklook", almost real-time, processor and as an off-line "Production" data analysis system. The system design incorporates the ability to perform both of these functions in parallel, and also to process large quantities of data in parallel. Figure 2-1 illustrates the designed system flow. This entire system is designed for operation on the SACC IBM 360/75 and 360/91 computers at GSFC.

The data input to the system is received from GSFC's Information Processing Division on magnetic tape in a previously defined format.[1] Quicklook and Production data both have the same data and file format, differing primarily in the accuracy of the satellite attitude and orbit parameters. Quicklook data is normally produced for one orbit per day, and is available within 8 hours of transmission, while Production data is produced for all telemetry, and is available within 6 weeks of transmission. In addition to the experiment data tapes, a Command Summary tape is produced by Marshall Space Flight Center and delivered to the experimenters. This tape contains only a record of commands sent and acknowledged by the satellite. The X-ray Source Catalog was compiled by the A2 experimenters, and incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disc file on a PDP-11/70 computer in the Laboratory for High Energy Astrophysics at GSFC.

---

[1] National Aeronautics and Space Administration, GSFC, X-565-77-60, Data Processing Requirements for High-Energy Astronomy Observatory A (HEAO-A), H. Linder, June 1977.

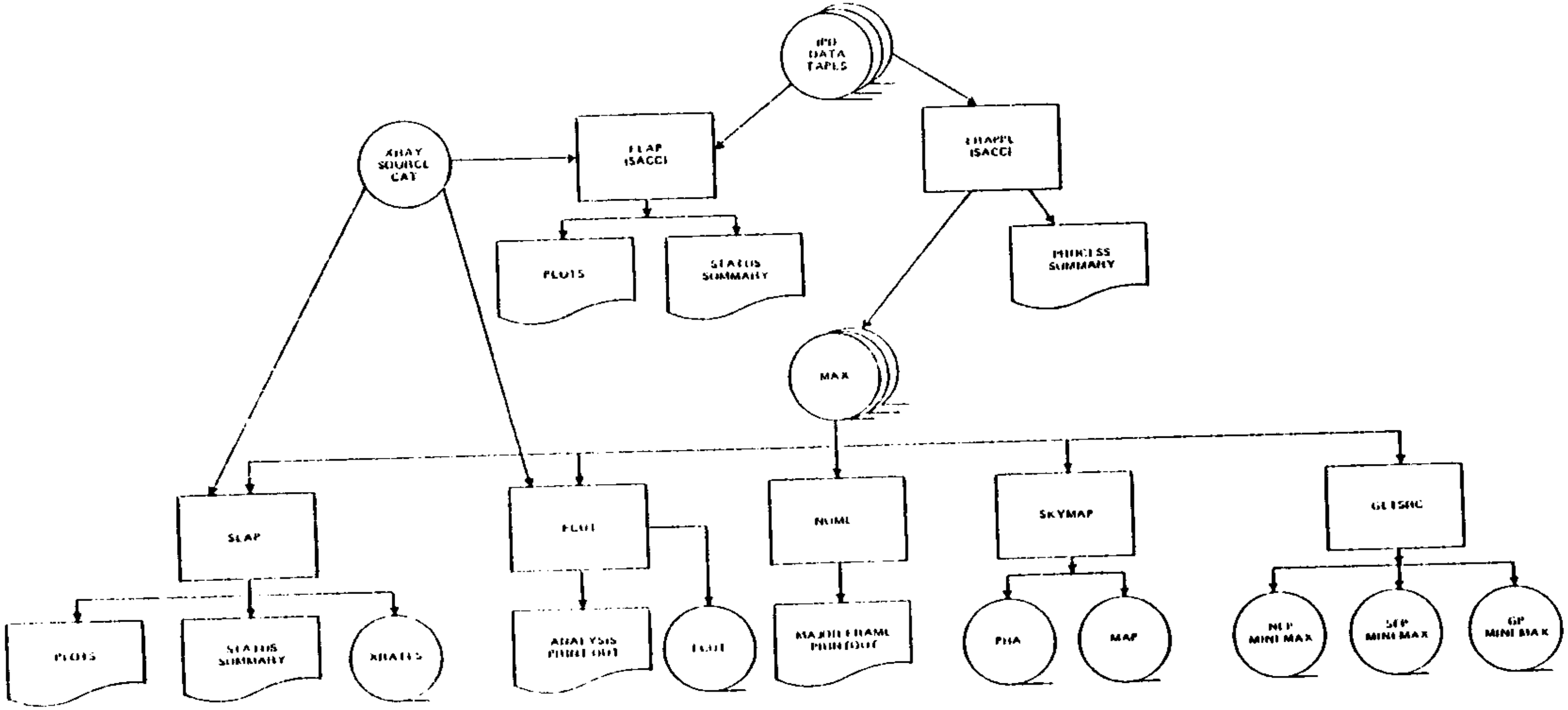


Figure 2-1. HEAO-A2 Data Processing System

The first processing of received data is a series of detailed tests to evaluate data quality and experiment health and status, and also a set of displays of some of the raw data in a way which allows some very preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

The next stage of data processing is the production of a restructured data base (MAX), which serves to ease the data analysis. This is done by re-formatting the data into a FORTRAN-accessible format, re-ordering the data from telemetry stream order to accumulation time order, and by setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Re-blocking and Production Processing Executive (FRAPPE) is the program which reads an IPD format tape and produces the MAX data base. Each file of the MAX data base normally contains 12 hours of data, with the file corresponding to a single spin axis position. Additional file marks are introduced when there are large gaps in the data.

A series of modules have been set up which use the MAX data base as input, and which perform preliminary analysis functions and also produce several condensed data bases.

The first of these modules is the Second Look Analysis Program (SLAP). This program generates a complete, detailed experiment status report, a complete set of detector counting rate plots, and a condensed data base (XRATES) of selected detector rates. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest. This program is used to process all Quicklook and Production data.

A second module is designed to produce a very detailed output from analysis of limited segments of data. This module, program NUMBER, examines the data on a Major Frame basis, and generates line printer output for a selected list of data including scaler counting rates, pulse height analysis, and temporal data. Full output for a Major Frame is approximately six pages long, and includes raw data and output from data analysis.

Another module is devoted to routine analysis of Production data. This program (FCUT) calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, performs a parameterization of the non-X-ray background, searches for new point sources, and performs a detailed analysis of the rates of known X-ray sources, forming a data base containing these last results.

Two more modules serve to create condensed data bases from the Production MAX data base. The first, program GETSRC, extracts Major Frame records from the MAX data base whenever a selected location of the sky is being observed, and places these records in time order on a separate output tape (MINI-MAX). This program will be used routinely to create tapes for the data for the North Ecliptic Pole, South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations will be created upon request using this program. The second module, program SKYMAP, creates up to three specialized data bases. The first of these data bases, MAP, contains Discovery scaler data, averaged over time, which is ordered by the observed location of the sky. The second data base, PHA, contains PHA data for Major Frames with good data. This program can also produce the XRATES data base mentioned above.

Detailed analysis programs will generally use the specialized data bases as input. The XRATES, MAP, PHA, and FCUT data bases are designed to allow their use with minicomputers, while the MINI-MAX data will normally be limited to large computers due to physical record size.

2.2 PROGRAM OVERVIEW

2.2.1 Introduction

The Frame Reblocking and Production Processing Exec Program serves as the main step in transforming the telemetry stream format of the IPD data into a format more easily analyzed by producing a restructured data base (MAX). This includes two primary functions: (1) reblocking the experiment, spacecraft, and orbit data so that all data relevant to a single major frame (40.96 seconds) will be present in one record of output data performing preliminary analysis of the data to set up a series of data quality flags indicating detector earth occultations, electron contamination and other quantities. Currently FRAPPE fully unpacks the following experiment formats: ROM1, ROM2, RAM1 - RAM10 (RAM2 - RAM8 are treated like RAM1), and partially unpacks the remaining formats, RAM0, and RAM11 - RAM15. Both quicklook and production data are processed by FRAPPE, the only difference being in the file structure of the MAX tapes produced. Quicklook MAX tapes contain one file for each quicklook orbit (approximately fifteen per volume). Production MAX tapes contain one file per 12 hour IPD tape (one spin axis position) and two files per volume, thus 24 hours of data per MAX volume. The only exception occurs when there is a gap between major frames on the IPD tape of more than ten major frames (409.6 seconds). In this case, a new file is started after the gap for both quicklook and production MAX tapes.

Every file on the IPD tape begins with one label record, followed by one or more orbit records, followed by a variable number of experiment data records. There are two experiment records for each major frame, one containing experiment data, and one containing spacecraft data. A discussion of the creation and contents of the IPD tape is contained in the document <u>Data Processing Plan for High-Energy Astronomy Observatory-A (HEAO-A)</u>[2] In particular, for the label record description, refer to TABLE 5-19, orbit record-Table 5-20, data record #1 - Table 5-26, and data record #2 - Tables 5-27 and 5-22. The label record, orbit records, and the spacecraft data records (type 2) are not affected by changes in memory format. The contents of data record #1 depend on the memory format in use, therefore Table 5-26 only tells which words from the spacecraft telemetry stream are read out (D (i, j), where j is the minor frame number and i is the word number in that minor frame). For a description of the ROM formats, refer to <u>HEAO A-2 Cosmic X-ray Experiment Technical Manual</u>[3] written by Richard Rothschild (pages 84-89). The RAM formats can be dumped and decoded as described on pages 90-92 of

[2] Ibid Reference 1

[3] Informal Document by R. Rothschild, May 1977

the Technical Manual. Refer to Appendix A of this document for a summary of the RAM formats that have already been programmed. For a description of the analog and digital status portion of the telemetry refer to the Technical Manual, pages 120-145.

Each MAX record is 15168 bytes long. The first record in each file is a header record with data in the first 84 bytes only. The first 80 bytes identify the IPD input tape volume serial number, the MAX output tape volume serial number, and the creation date. Bytes 81-84 contain a four-byte integer which will be zero for production data and one for quicklook data. All of the subsequent records in the file have a 64-byte section at the beginning which contains the day, time, memory format, and all flags. Depending on the memory format, this introductory section is followed by:

RAM0 (accelerated housekeeping)	- digital and analog status data record #1 error flags data format flags
ROM1, ROM2, RAM1 - RAM10	- digital and analog status data format flags data record #1 and #2 error flags clock bytes attitude data orbit data calibration data housekeeping scalers discovery scalers either pha data or temporal data
RAM11 - RAM15	- digital and analog status data format flags data record #1 and #2 error flags clock bytes attitude data orbit data housekeeping scalers 6144 bytes of telemetry data

A discussion of each type of data appearing in the MAX database follows. Appendix B gives the variable names and locations in the MAX records.

2.2.2 CALCULATED DATA QUALITY FLAGS

The ten data quality flags in the introductory section of each record are determined as follows:

1) General data quality flag (HERRF) - based on three types of errors:

   a) Block encoder errors - In the experiment electronics the telemetry is sent through a pattern of exclusive and non-exclusive OR's and the resulting number is stored in words 19,20,21,22 of the digital status in the next major frame. In the program, the experiment telemetry is sent through the same pattern of OR's and if the resulting number does not agree with the number sent by the spacecraft, a transmission error from spacecraft to ground has occurred. This is referred to as a block encoder error, and the test is made only if there are no fill data and no bit errors.

   b) Bit errors - Data records #1 and #2 have 128 flag fields (in byte 66-50N, N=0,1,...127 for data record #1, in byte 45+32N, N=0,1, ...127 for data record #2, bits 1-5) which give the number of bit errors (improperly received bits) in each minor frame. If any are greater than zero, the major frame has bit errors. These are errors detected by IPD in the transmission from the ground station to GSFC.

   c) Fill data - The same flags as described in b) above indicate if there's fill data (missing data) in any minor frame. If bit eight of any of the flags is set, there is fill data in the major frame. The minor frame flags from data record one and two are saved for output also (QERR1, QERR2 respectively).

The format of HERRF is

HERRF = 0:	no errors
2**0 bit = 1:	block encoder error
2**1 bit = 1:	bit error
2**2 bit = 1:	fill data

HERRF is made negative when a major frame is incomplete (which happens when the subsequent frame is not available). This is the case for the first and last major frame record of every file and for the first major frame record after a gap in the data. In the first case, it would be possible to get the full set of major frame data by looking at the last major frame of the preceding IPD tape.

2) Engineering/Science format flag (HENGF) - This flag is set if the spacecraft telemetry is in the engineering mode. No experiment data is sent in the engineering mode. There are 128 flags in data record two (byte 42+32N, N=0,1,...127, 2**5 bit =0 indicates engineering, 2**5 bit = 1 indicates science) indicating whether science or engineering format is used in each minor frame. The flags from the next major frame that correspond to data that belongs to present major frame are checked as well as flags from the present major frame.

The format of HENGF is

HENGF = 0: all data in major frame is science format data

HENGF = 1: some data is engineering format data

The 128 minor frame flags are saved also as a separate array (QD FORM).

3) Earth occultation flags

The earth occultation flags indicate, for each detector, whether the earth is in the field of view of that detector for any part of the major frame. The first occultation flag (HEOCC1) is set if any part of the "bare" earth is in the field of view, while the second flag (HEOCC2) is set if the earth plus one hundred kilometers of atmosphere is in the field of view.

The occultation calculation is performed using the satellite altitude, satellite velocity vector, and satellite geocentric coordinates (available once per major frame), along with the spacecraft attitude data (available 32 times per major frame). For three times corresponding to the beginning, middle and end of the major frame, the angle of the earth horizon (or earth + 100 km horizon) from the center of the earth as viewed from the spacecraft, and the celestial coordinates of the center of the earth are calculated. For the bare earth, the earth horizon angle is given by

$$\sin \phi = Ro/(Ro + h)$$

where φ is the earth horizon angle

Ro is the earth radius

h is the satellite altitude

Then, using the spacecraft attitude data, a calculation is made to check if any portion of the earth is in the large field of view of the detector at these three times. If the earth is observed for any of these times, then the flag is set.

The format of the occultation flags is:

HEOCC1, HEOCC2 = 0 no detector occulted

2^0 bit set, LED1 occulted

2^1 bit set, LED2 occulted

2^2 bit set, HED1 occulted

2^3 bit set, HED2 occulted

2^4 bit set, MED occulted

2^5 bit set, HED3 occulted

4) Electron contamination flag (HECONF) - The electron rate is calculated as follows:

$n_i = h_{9_i} - t_1 h_{9_i}^2 - b_i (h_{8_i} - t_2 h_{8_i}^2 - c_i)$ i = 1, 2, 4, 5 (Detectors LED1, LED2, MED + HED2)

$n_i = h_{9_i} - t_1 h_{9_i}^2 - b_i (h_{7_i} + t_2 h_{7_i}^2 - c_i)$ i = 3, 6 (Detectors HED1 + HED3)

where h_{7_i}, h_{8_i}, h_{9_i} are the seventh, eighth, and ninth housekeeping scaler for the i^{th} detector

b_i = constants dependent on detector

$b_1 = 1.1004$

$b_2 = 1.12109$

$b_3 = .80$

$b_4 = 1.51$

$b_5 = 1.42$

$b_6 = .86$

$$c_i = c^1_i \, e^{(d_i - d)/1422}$$

where c^1_i = constants dependent on detector

$c_1^1 = 392.4$

$c_2^1 = 353.89$

$c_3^1 = 691.00$

$c_4^1 = 805.27$

$c_5^1 = 763.90$

$c_6^1 = 1093.22$

d = current day based on January 1, 1977

d_i = day at which strength of calibration sources were measured, with day 1 being January 1, 1977

$d_1 = -270$

$d_2 = -264$

$d_3 = 70$

$d_4 = 70$

$d_5 = 70$

$d_6 = 70$

$t_1 = 2.7 \times 10^{-7}$

$t_2 = 7.3 \times 10^{-8}$

If housekeeping scaler nine is greater than 30000, or the electron rate is less than -600, or the electron rate is greater than, the predetermined limit, the flag is set to contaminated for that detector. The limits for each detector are:

LED1	:	600
LED2	:	600
HED1	:	1000
HED2	:	700
MED	:	600
HED3	:	500

It should be noted that the contamination constants, and thus these flags, are at best first order approximations for the LED's. The constants and limits for the MED and HED's are the results of a study of experiment data by Dr. A. Rose of GSFC. The format of the flag is:

2**1, 2**0 bits = LED1
2**3, 2**2 bits = LED2
2**5, 2**4 bits = HED1
2**7, 2**6 bits = HED2
2**9, 2**8 bits = MED
2**11, 2**10 bits = HED3

bits = 00 = no electron contamination
bits = 11 = electron contamination

6) Magnetic field direction flag (HMAGF) - The angle between the magnetic field vector and detector axis vector is computed for both deck and offset detectors:

$$\varphi_d = \arcsin\left(\sqrt{1 - y_B^2}\right) \quad \text{for deck detectors}$$

$$\varphi_o = \arcsin\left(\sqrt{1 - (y_B \cos 6^\circ - X_B \sin 6^\circ)^2}\right) \text{for offset detectors}$$

where X_B = x coordinate of magnetic field relative to y axis of spacecraft (word 1509 of data record 2)

Y_B = y coordinate of magnetic field relative to y axis of spacecraft (word 1510 of data record 2)

If φ_d or φ_o is within 2^o of 0^o, or within 2^o of 90^o, the flag for the deck detectors or offset detectors is set. The format of the flag is:

2**0 bit = LED1

2**1 bit = LED2

etc.

bit = 0 = field is neither parallel nor perpendicular to detector axis

bit = 1 = field is either parallel or perpendicular to detector axis

7) High voltage flag (HVFLAG) - This flag is set for each detector if the high voltage is turned off and remains set for two major frames after it is turned back on. The high voltage power on/off indicator is in bytes 25, 38, and 51 (2**4 bit = 1 indicates power on) of the digital status (bytes 2418, 3817, and 4018 of data record one) for detectors 1, 2, 3 if the major frame counter is even, and detectors 4, 5, 6 if the major frame counter is odd. The format of the flag is:

2**0 bit = LED1

2**1 bit = LED2

etc.

bit = 0 = high voltage on and not within two major frames of turn on.

bit = 1 = high voltage off, or high voltage on but within two major frames of turn on.

8) South Atlantic Anomaly/North Pacific Anomaly and sunlight flag (HSANPF) - This flag indicates whether the satellite is in the region of the South Atlantic Anomaly (SAA) or the North Pacific Anomaly (NPA) or in sunlight during the major frame. The SAA is defined by the trapezoid with the following vertices in (geodetic latitude, geodetic longitude): $(-3^o, -55^o)$, $(-3^o, -10^o)$, $(-23.5^o, -80^o)$, $(-23.5^o, 25^o)$. The NPA is the region with

geodetic latitudes >18^{o} and geodetic longitudes between 190^{o} and 250^{o}. The geodetic latitude and longitude of the satellite are found in words seven and eight of the orbit data. Word 24 of the orbit data indicates whether the satellite is in sunlight or shadow (0 = shadow, 1 = sunlight). The format of HSANPF is:

2**0 bit = SAA/NPA

bit = 0 not in SAA or NPA

bit = 1 in SAA or NPA

2**1 bit = sunlight

bit = 0 not in sunlight

bit = 1 in sunlight

9) Thruster counter (HJETPS) - number of thruster firings during major frame gotten by adding bytes 582, 613 and 614 (which are miscellaneous DPA data) of data record two together. This sum is the number of thruster firings during the previous major frame and is stored in the previous major frame's common block.

10) High voltage stability flag (HVST) - The high voltage for a detector is stable when the voltages in the previous, current, and subsequent major frames are within 4 volts of a specified value and are within 2 volts of each other. The specified value for each detector is:

119.66 volts - LED1
131.04 volts - LED2
97.10 volts - HED1
99.19 volts - HED2
121.02 volts - MED
84.04 volts - HED3

The high voltage values are found in words 3, 7, 11, 15, 19, and 23 of the analog status for detectors 1 - 6 respectively. The format of HVST is:

2**0 bit = LED1

2**1 bit = LED2

etc.

bit = 0 = stable

bit = 1 = unstable

2.2.3 Experiment Status and Spacecraft Data Processing

A large amount of data is transferred to the MAX tape to give a complete and accurate record of the state of the experiment and also of the spacecraft. Experiment status data consists of a set of packed bit parameters giving a detailed picture of the experiment command state, and also a set of digitized analog parameters. The data processed for the spacecraft includes orbit and attitude data, the internal spacecraft telemetry clock, and a variety of parameters which record the general environment.

The last 6 bytes of the introductory section of each MAX record contain one byte of Data Processing Unit (DPU) status for each of six detectors. They come from the following words in data record one:

6022 - 6027	ROM1 Format
6067 6068 6069 6091 6092 6093	ROM2 or RAM Formats (Except RAMO)

and have the following meaning (most significant four bits):

State	ΔT computer mode	resolution
0x00	I	1.25 ms
0x01	I	2.50 ms
0x10	I	5.00 ms
0x11	I	10.00 ms
1000	II	10.00 ms
1001	II	20.00 ms
1010	II	40.00 ms
1011	II	80.00 ms
11x0	III	39.00 us
11x1	III	78.00 us

(least significant four bits)

2^3 bit	= 0	Discovery Scaler MSB time = 5.12 sec	
	= 1	" " " " = 1.28 sec	
2^2, 2^1 bits	= 00	PHA MSB time = 40.96 sec	
		LSB time = 10.24 sec	
	= 10	PHA MSB time = 10.24 sec	
		PHA LSB time = 10.24 sec	
	= 11	PHA MSB time = 40.96 sec	
		LSB time = 40.96 sec	
	= 01	Illegal state	

The least significant bit is not used.

The first two bytes of every sequence (four minor frames) in data record #1 contain experiment digital status. These 64 bytes are stored in array QDSTAT on the MAX tape. The digital status has two sections - experiment and detector status. A full cycle of experiment status is contained in one major frame, while only a half cycle of detector status is in one major frame. The even major frames have the detector status for LED1, LED2 and HED1, and the odd major frames have the detector status for HED2, MED, and HED3. Occasionally the digital status becomes (FF) and stays (FF) for the rest of the major frame. This indicates that the experiment will be in dump mode for the next three major frames, i.e. the entire contents of the memory format are read out in place of standard status for the next three major frames.

The third byte of every sequence in data record #1 contains experiment analog status. These 32 bytes are stored in array QASTAT on the MAX tape. It takes eight major frames to read out the entire analog status with the following four exceptions: the differential pressure for LED1 and LED2, the regulated 20 volt current, and the high voltage value for each detector come out every major frame. The data contained in the analog status for a particular major frame depends on the major frame counter (see HEAO A-2 Cosmic X-ray Experiment Technical Manual, pp. 120-125).[4]

In addition, the status of several vital power busses are saved (HBUS, HEAA2), and that of the stand-by heaters (HA2STB). The temperatures of the spacecraft-experiment interfaces are also saved (HT1, HT2).

The spacecraft internal clock is a 28 bit counter incrementing once for each minor frame. 20 bits of this counter are read-out in each minor frame. (0.32 sec) The remaining bits are read out once per major frame (40.96 sec.). The value of this counter is calculated and saved as a 28 bit counter for each minor frame (ICLOCK). The least significant 20 bits are found in data record two. From least significant to most significant the data words are D(130, j), D(129, j), and the least significant four bits of D(128, j). The most significant eight bits are in word D(81, j) in minor frame 119 (of 128).

The spacecraft attitude data transferred consist of the spacecraft spin (Z) and Y axis, positions and errors, gyro drift rates, the raw quaternions, and a flag field. The spin and Y axis positions are given for each 1.28 seconds, with the first value on the output tape corresponding to 0.96 seconds after the major frame time. These positions are given in both Celestial (Epoch 1950) and Galactic coordinates. The data are extracted from the Data Record two, with the first value on the output tape being the second value found on the output tape. The gyro drift rates are given for the x, y, and z components in radians/second. The attitude flag field is currently not used, and contains zero's. The quaternions are the raw data for determining the attitudes. Their meaning and use are described in a series of NASA documents.[5]

---

[4] Ibid Reference 3

[5] HEAO-A Attitude Control and Determination Support Software Requirements - NASA, Marshall SFC, 72M10103, Revision A, Dec. 7, 1976, also Appendix A - 10 Dec. 1976, App. B - 19 Jan. 1977, App. C - 10 Dec. 1976, App. D - 14 Dec. 1976.

Additional information about the spacecraft environment includes the value of the magnetic field vector, the McIlwain L parameter and the direction of the center of the earth in spacecraft coordinates, all given once per major frame. The magnetic field is given as an intensity (ODATA (17) in gauss), as a unit vector in spacecraft coordinates (x,y,z, components in B), in geocentric coordinates (r, φ, ϕ in ODATA (18) - ODATA (20) respectively), and in Celestial Coordinates (Right Ascension and Declination in ODATA (21) and ODATA (22)). The McIlwain L Parameter is given in units of earth radii (ODATA (16)). The direction to the center of the earth is given in the form of two angles, the angle from the spacecraft z axis to earth center (PHIEAR in radians), and the rotation angle about the z axis, with the spacecraft y axis taken as zero (THEAR in radians).

Also, selected orbital parameters are used. These are present on the input tape as a separate set of data, with values given for each minute of time. These values are interpolated to the time of the start of the major frame, and included in the output record for that major frame. These items include:

1) The satellite position vector (geocentric coordinates in km.)
2) The satellite velocity vector (geocentric coordinates in km per second)
3) Geodetic longitude and latitude (degrees)
4) Satellite altitude (km)
5) Inertial sun unit vector
6) Inertial Lunar position vector (km)
7) Solar time: the angle between the sun-earth and satellite earth directions (degrees)
8) The angle between the subsatellite point and the earth horizon, accurate to about one degree (radians)
9) A flag set to one if the satellite is in sunlight, or zero if in shadow.

There are ten 40.96 second housekeeping event rates for each detector:

M1
$R1 \cdot \overline{L1}$
$L1 \cdot \overline{R1}$
M2
$R2 \cdot \overline{L2}$
$L2 \cdot \overline{R2}$
V1
V2
$\geq Z$
$\overline{M1}$ overdrive

These 10 housekeeping scalers are accumulated in one major frame and read out in the next. Therefore all ten are always stored back one major frame on the MAX tape. They are the raw counting rates for the given detector element, or logic trigger.

The eight discovery scalers are defined by the experiment status. The first four are normally defined to be, respectively,

Layer 1, left field of view
Layer 1, right field of view

Layer 2, left field of view
Layer 2, right field of view

for all events accepted as good X-rays.

There are two readout modes for the discovery scalers. Normally the 1.28 second accumulation is readout as an 8 bit number, with the most significant 8 bits of the 5.12 second accumulation readout and combined with the 1.28 second LSB's to get the correct 16 bit accumulation. In the accelerated mode, the LSB and the MSB are both read out every 1.28 seconds as a 16 bit accumulation. The accelerated mode is used only in the RAM's that are not unpacked (RAM 11 - RAM 15), since the LSB readouts are accumulated in one 1.28 second sequence and read out in the next, the accumulation ot the last 1.28 second sequence in a major frame is read out in hte next major frame on the IPD tape. The same is true for the 5.12 second MSB. In order to reblock the data so that all data accumulated during a mojor frame is present in that frame on the MAX tape, the first LSB and MSB readouts of the subsequent major frame are associated with the last three LSB readouts of the current major frame to form the eighth occurrence of each scaler in the current MAX record. The second, third, fourth and fifth LSB readouts of a frame are associated with the second MSB readout of that frame to form the first occurrence of each scaler in that MAX frame record. The algorithm for computing the 5.12 second sum from the four LSB's and MSB is:

$$SUM = (MSB - K) * 256 + \sum_{i=1}^{4} LSB_i$$

$$\text{where } k = \sum_{L=1}^{3} (\text{bit \#8 of } LSB_i)$$

All standard formats have discovery scaler data, however, all of the RAM's, except RAM9 have no MSB's for detectors LED2, HED1, and HED3, for scalers 5-8. The 5.12 second rates for these scalers are formed as simple sums. Discovery scaler data is stored in array HDSC (I, J, K, L) on the MAX tape, where:

I = 1, 5	4	1.28 sec. readouts, 1 5.12 sec sum
J = 1, 8	8	occurrences in major frame
K = 1, 8	8	scalers
L = 1, 6	6	detectors

There are 128 channels of PHA histogram data which are read out in one of three modes:

Mode A - LSB and MSB every 10.24 seconds

Mode B - LSB and MSB every 40.96 seconds

Mode C - LSB every 10.24 seconds and MSB every 40.96 seconds

Since the LSB's and MSB's are accumulated in one 10.24 or 40.96 second interval and read out in the next, the fourth 10.24 second readout for a major frame appears as the first 10.24 second readout in the next major frame, and the 40.96 second readouts for a major frame all appear in the next major frame. On the MAX tape all PHA data accumulated during a major frame appears in the record for that major frame. For example, in mode C, the first LSB and the MSB in major frame B are stored back as the fourth LSB occurrence and the MSB of MAX frame A. The second, third, and fourth LSB's of frame B are now the first, second and third LSB occurrences of MAX frame B. PHA data is read out and appears on the IPD tape with the contents of channel 128 first and channel one last. On the MAX tape, the order is reversed and the channels appear in the proper order. The algorithm for computing the 40.96 sum for each channel is:

Mode A : $\text{Sum} = \sum_{i=1}^{4} (LSB_i + MSB_i * 256)$

Mode B : $\text{Sum} = LSB + MSB * 256$

Mode C : $\text{Sum} = (MSB-K) * 256 + \sum_{i=1}^{4} LSB_i$

where $K = \sum_{i=1}^{3} (\text{bit \#8 of } LSB_i)$

For the formats which are unpacked by FRAPPE, the following modes are used:

ROM1	-	C	
ROM2	-	has no pha data	
RAM1	-	B (no MSB's)	
RAM 9	-	C HED1	
		C HED2	
		C MED	
		A HED3	
RAM10	-	C LED1	
		B LED2	(no MSB's)
		C HED1	
		B HED2	(no MSB's)
		C MED	
		C HED3	

PHA data is stored in array HPHTMP (3840) on the MAX tape. Refer to appendix B for the locations used for the different formats.

Temporal data can be in one of three modes, in which the Δt computer asks the question:

Mode I - Any event in Δt? Δt = 1.25, 2.5, 5.0, or 10 milliseconds.

Mode II - How many events in Δt? Δt = 10, 20, 40, or 80 milliseconds

Mode III - What time to the first eight events in Δt ?

Δt = 80 milliseconds, resolution = 39.0625 microseconds or

Δt = 160 milliseconds, resolution = 78.125 microseconds.

Information as to what mode and value of Δt are in use is contained in the DPU status words as described above. For each detector, there are 16 occurrences of 32 readouts (ROM II, mode II and all RAMs) or 40 readouts (ROM II, modes I and III). In all cases except ROM II, mode II, the temporal data is copied directly into the appropriate locations in array HPHTMP (see appendix B). In ROM II, mode II, the data is recombined as follows: Even sequences have 24 readouts for detectors LED I, LED II, and HED I of which every third is combined with the previous two. The left four bits of the third readout are the most significant bits for the first readout, and the right four bits are the most significant bits for the second readout. The 24 readouts become 16 12-bit readouts. Odd sequences have the remaining 16 readouts (8-bit) for detectors LED I, LED II and HED I. Similarly, for detectors HED II, MED, and HED III, the odd sequences contain 24 8-bit readouts which must be recombined to form 16 8-bit readouts, and the even sequences contain 16 8-bit readouts. The temporal mode used most frequently at present is MODE II with Δt = 80 milliseconds. All temporal data that is read out in one major frame of the IPD tape is put into one MAX major frame, even though the first two readouts (in the MODE II case) were accumulated in the previous major frame. The following standard formats have temporal data, normally in Mode II with Δt = 80 milliseconds: ROM2, RAM1, RAM9, RAM10. Temporal data is stored in array HPHTMP (3840) on the MAX tape. Refer to appendix B for the locations used for the different formats.

2.2.4 Program Design

The overall structure of program FRAPPE is shown in the Hierarchy Diagram (Figure 2-1) and in the Subroutine Cross-Reference Table (Table 2-1). Six of

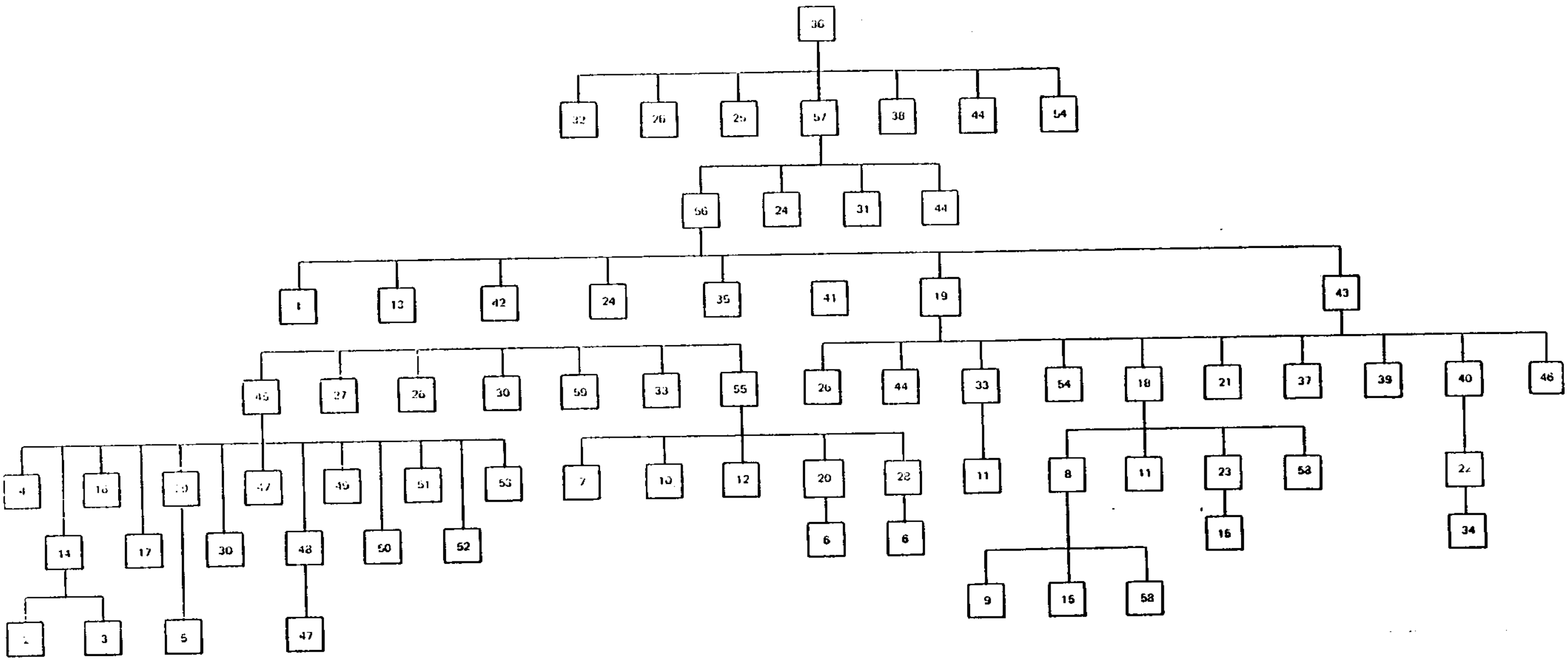


Figure 2-2. FRAPPE Hierachy Diagram

HIPO TABLE OF CONTENTS

21.	ESSBUS:	Extracts essential & non-essential bus information, standby heater, and temperature data
22.	FIND2R:	Search the orbit data for time closest to the major frame time
23.	FOVIEW:	Determines if an object is in the field of view of a detector
24.	FREAD:	Reads a record (FTIO routine)
24.	FTRAP:	Detects end-of-volume (FTIO routine)
25.	FWRITE:	Writes a record (FTIO routine)
27.	GAP:	Completes reader record for 'fake RAM0' frames
28.	GTRAM0:	Transfers all data to output common for format RAM0
29.	HSKPGS:	Driver for extracting housekeeping scalers
30.	INDIRT:	Calls a subroutine indirectly to allow addressing of an I/O buffer
31.	INDRCT:	Same as INDIRT (allows for two levels of indirect subroutine calling)
32.	INITD:	Initializes variables and reads input parameters
33.	INTATT:	Extrapolates 32'nd attitude data when it is unavailable
34.	INTERP:	Interpolates orbit data to major frame time
35.	LABEL:	Prints the IPD label record
36.	MAIN:	Overall control of processing
37.	MGFLD:	Sets the North Pacific/South Atlantic Anomaly/sunlight flag
38.	MOUNT:	Mounts a magnetic tape (FTIO routine)
39.	NPAFLG:	Sets the North Pacific/South Anomaly/sunlight flag
40.	ORBITR:	Computes time of major frame and calls FIND2R to get closest orbit data
41.	ORBITW:	Saves orbit data for a file in common ORBITC
42.	PART1:	Controls processing of data record #1 and writes MAX record
43.	PART2:	Controls processing of data record #2
44.	POSN:	Positions to a specified file (FTIO routine)
45.	PREVMF:	Completes previous major frame with data from current major frame that must be set back

46. RESTDA: Stores data record #2 information into common OUTBUF

47. SRAM1: Handles extraction of data unique to RAM1 format

48. SRAM10: Handles extraction of data unique to RAM 10 format

49. SRAM11: Handles extraction of data unique to RAM's >10 format

50. SRAM9: Handles extraction of data unique to RAM9 format

51. SROM1: Handles extraction of data unique to ROM1 format

52. SROM2: Handles extraction of data unique to ROM2 format

53. STRATT: Stores the first attitude data occurrence into the previous major frame's 32nd occurrence.

54. SUMOUT: Prints summary output

55. THISMF: Transfers data that was accumulated during current major frame into common OUTBUF

56. TVPRCI: Controls processing of an IPD record

57. TVPROC: Reads an IPD record and calls TVPRCI to process it; handles EOF and EOV on IPD tape

58. UNITV: Calculates unit vector

59. ZEROAT: Determines whether the attitude data is valid.

the routines (Subroutine INDRCT, and those whose name starts with the letter "A") are coded in assembly language, while all others are coded in FORTRAN for use with the IBM lever H compiler.

For understanding of the program structure one must note several factors. The input data structure is the dominant factor. One multi-file input tape volume normally corresponds to a single file on the out put data tape. Each file of the input data is in the following order: a header record, a set of orbit data records covering the time of the spacecraft data, followed by pairs of spacecraft and experiment data. Another factor is the use of the input data buffers as the access area of core for the purpose of reducing the movement of data from one place to another in core memory. This required the creation of several routines for accessing the data buffers. In particular, most routines are called indirectly through routine INDRCT (INDIRT is equivalent, and is used to avoid re-entry problems) which sets up the data addresses for FORTRAN usage.

The main routine controls the tape volume handling. It first calls INIT to read input data from cards for variable initialization, the list of tapes, and the list of output file headers. It then completes initialization of variables, mounts the output tape, and, for each input tape (up to 10), it mounts the input tape, calls TVPROC to process the input volume, and calls SUMOUT to print a summary of the volume and put an end of file on the output tape.

TVPROC reads a record from the IPD tape into a buffer and calls TVPRCI through INDRCT to process the record. At end of file, TVPROC positions to the next file and checks for end of volume. Also, under certain error conditions (I/O error on IPD tape; time gap between data records #1 and #2), TVPROC will stop the program. TVPRCI determines the type of record that is in the buffer and handles it accordingly:

Label record - LABEL is called to print the label data

Orbit record - ORBITW is called to save the orbit data in a common area for later combination with the experiment and spacecraft deck.

Data record #1 - PART 1 is called and data record #2 is read into the second buffer

Data record #2 - PART 2 is called

If a gap of more than 409.6 seconds (10 major frames) occurs between major frames, TVPRCI calls EOFGAP to start a new file on the MAX tape.

To handle the problem of reblocking data by accumulation time, PART 1 has two distinct sections. First the data that appears in the current major frame but was accumulated in the previous major frame (including some data from data record #2) is transferred to the output common area OUTBUF, and the remaining flags in OUTBUF are set. OUTBUF now contains the complete previous major frame and is written onto the MAX tape. Secondly, OUTBUF is cleared and the data that appears in the current major frame <u>and</u> was accumulated in the current major frame is transferred to OUTBUF. PART 2 then transfers the data from data record #2 that belongs in the current major frame into OUTBUF. This major frame will be completed in the subsequent call to PART 1.

More specifically, PART 1 first extracts the memory format from data record #1 and checks that it is valid. If so, PREVMF is called to extract <u>all</u> the data from the current major frame and transfer the appropriate parts to the previous major frame in the output common OUTBUF. The previous major frame is now complete and is written on the MAX tape. Common OUTBUF is reinitialized to fill characters (hex 'AA'), and THISMF is called to start filling in OUTBUF with data from the current major frame. There are three cases in which the data is not extracted and saved in PREVMF:

1. The memory format is invalid.

2. A RAM format directly follows a different RAM format.

3. The record is in memory dump mode.

In these cases, PREVMF is called but handles the record as though it had format RAM0, i.e., a minimum of extraction is done and no data is stored back to the previous major frame. For these three cases and a fourth case - the current major frame has no attitude data - THISMF is not called. The frame is made a 'fake RAM0 record', i.e., GAP is called to set the ROM number (HMFORM) to -3, the RAM number (HRAM) to 0, and the error flag (HERRF) to 4, and no data is transferred to common OUTBUF for the major frame from either data record #1 or data record #2. In the subsequent call to PART 1 with the next record, no data is stored back to this major frame. Another problem PART 1 handles is time gaps between major frames (i.e., the current major frame is more than 40.96 seconds later than the previous one.) In this case PREVMF is called to extract data, but no data is stored back to the previous major frame. 'Fake RAM0' frames with times incremented by 40.96 seconds from the last good frame are written until the gap is filled, and then THISMF is called to transfer the current major frame's data into common OUTBUF.

PREVMF is the driver for extracting the data from data record #1, and completing the previous major frame's common block with data from both data records #1 and #2 that must be stored back. Discovery scalers, housekeeping scalers, and pha/temporal data are extracted and stored through calls to DISCSC, HSKPGS and depending on memory format, SROM1 (ROM1), SROM2 (ROM2), SRAM1 (RAM1-RAM8), SRAM9 (RAM9), or SRAM10 (RAM10). For formats RAM11 - RAM15, SRAM11 is called to copy the telemetry stream data into array HPHTMP in the same order as it appears on the IPD tape. The clock and flag bytes are excluded. As data is extracted, the data record #1 error flag corresponding to the minor frame that the data came from is checked. If the flag indicates bit errors, the data is made negative. If the flag indicates fill data, the data is set equal to fill characters (hex 'AA'.) Each time data is moved from the temporary arrays to OUTBUF, it is checked for negative values or fill values and counters keeping track of the number of bit errors and fill data are updated.

PREVMF also sets the high voltage flag, the high voltage stability flag, the general data quality flag, calls ECOUNT to set the electron contamination flag, and calls DPAFLG to set the thruster counter. DPAFLG is called through INDIRT, since the thruster firings data is in data record #2 which is in the second buffer. If the current major frame is in accelerated housekeeping (RAM0), no science data is extracted or stored, but the flags are set. If the previous major frame was in RAM0 or was a fake RAM0 frame, or if the memory format has changed, all data is extracted, but none is stored back to the previous major frame.

THISMF is responsible for transferring the data that was extracted from the current major frame (data record #1) into common OUTBUF. For all formats except RAM0 and RAM > 10, the appropriate discovery scalers, pha data and temporal data are transferred from the temporary arrays to OUTBUF. Also CAL, DASTAT, CSTAT and ERROR are called to extract and store in OUTBUF the calibration data, digital and analog data, command status words, and data record #1 error flags. For major frames in RAM > 10, discovery scalers are not transferred and CAL is not called. For major frames in RAM0, a separate routine, GTRAM0, is called to copy all the accelerated housekeeping data into OUTBUF.

PART 2 has control over storing into OUTBUF the orbit and attitude data and setting the flags that are based on data record #2 information. It sets the engineering/science format flag and calls EOCC, MGFLD, and NPAFLG to set the earth occultation flags, the magnetic field direction flag, and the North Pacific/South Atlantic anomaly flag. ESSBUS is called to store the essential and non-essential buss words and standby heater and temperature information. ORBITR is called to find the closest set of orbit data to the major frame, interpolate it to the major frame time, and store it. RESTDA is called to store the remaining data record #2 information: spacecraft clock, attitude data (only the second through the 32nd occurrences - the first was stored back to the previous major frame), quaternions, and data record #2 error flags. All memory formats are handled indentically except RAM0, for which only the data format flags are stored. If the frame is a 'fake RAM0' frame, no processing is done by PART 2.

The common block usuage is shown in Figure 2-4. OUTBUF contains the major frame data that is to be written in one record of the MAX tape; DATAR contains information about the current major frame such as memory format, major frame counter, and dump mode flag; HOLD contains 128 data record #1 error flags and a summary error flag; HOLD 2 contains the temporary arrays in which science data is stored by PREVMF before being moved into OUTBUF; PREV contains the flag indicating whether the previous frame was stored and the counters for bit and fill data.

Calling Subprogram \ Called Subprogram	ADDR	ADISC	ADSRI	AFLAGS	AHOUSE	BLOCK	CAL	CONVEC	CROSS	CSTAT	CVXYZ	DASTAT	DAYSEC	DISCSC	DOT	DPAFLG	ECOUNT	EOCC	EOFGAP
CONVEC									•						•				
DISCSC		•	•																
EOCC								•			•								
EOFGAP																			
ERROR						•													
FIND2R																			
FOVIEW															•				
GTRAM0						•													
HSKPGS					•														
INTATT											•								
MAIN																			
ORBITR																			
PART1																			
PART2																		•	
PREVMF				•										•		•	•		
SRAM10																			
THISMF							•			•		•							
TVPRCI	•												•						•
TVPROC																			

Calling Subprogram \ Called Subprogram	ERROR	ESSBUS	FIND2R	FOVIEW	GAP	GTRAM0	HSKPGS	INDIRT	INDRCT	INITD	INTATT	INTERP	LABEL	MGFLD	NPAFLG	ORBITR	ORBITW	PART1	PART2
CONVEC																			
DISCSC																			
EOCC				•															
EOFGAP											•								
ERROR																			
FIND2R												•							
FOVIEW																			
GTRAM0																			
HSKPGS																			
INTATT																			
MAIN										•									
ORBITR			•																
PART1					•			•			•								
PART2		•												•	•	•			
PREVMF							•	•											
SRAM10																			
THISMF	•					•													
TVPRCI													•				•	•	•
TVPROC									•										

Calling Subprogram \ Called Subprogram	PREVMF	RESTDA	SRAM1	SRAM10	SRAM11	SRAM9	SROM1	SROM2	STRATT	SFMOUT	THISMF	TVPRCI	TVPROC	UNITV	ZEROAT	FREAD	FWRITE	FTRAP	MOUNT
CONVEC														•					
DISCSC																			
EOCC														•					
EOFGAP										•							•		
ERROR																			
FIND2R																			
FOVIEW																			
GTRAM0																			
HSKPGS																			
INTATT																			
MAIN										•			•				•	•	•
ORBITR																			
PART1	•										•				•		•		
PART2		•																	
PREVMF			•	•	•	•	•	•	•										
SRAM10			•																
THISMF																			
TVPRCI																•			
TVPROC												•				•			

Subprogram Cross - Reference

Figure 2-2

Used by Subprogram \ Common Block	BUFFER	BUFFR2	CONST	DATAR	DETCOM	FOCCOM	ERRORS	FOVCOM	GAPCOM	GETADR	HOLD	HOLD2	INITCM	INTCOM	LBLHDR	ORBITC	OUTBUF	OUTTAP	PREV	PRTCOM	QIKCOM	SAVE	SUMCM2	SUMCOM	SUMORE	TABLES	TMPTAB	TOLER	YRCOM
DDR	●																					●							
ADISC	●			●							●																		
DSR1	●			●							●																		
AFLAGS	●										●																		
AHOUSE	●			●							●																		
BLOCK	●			●																									
CAL				●							●						●		●										
CSTAT				●													●												
DASTAT				●							●						●												
DAYSEC									●																				
DISCSC				●							●						●		●			●				●			
DPAFLG				●													●		●										
ECOUNT											●						●											●	●
EOCC			●			●											●												
EOFGAP				●					●				●	●	●		●	●							●				
ERROR				●													●		●										
ESSBUS																	●												
FIND2R																●				●									
FOVIEW					●			●																					
GAP																	●												
GTRAM0											●						●		●										
HSKPGS				●							●						●		●							●			
NITD													●	●	●		●	●						●				●	
NTATT																	●												
INTERP						●											●			●									
LABEL																													●
MAIN													●	●	●		●	●			●			●	●				
MGFLD			●														●											●	
NPAFLG																	●												
ORBITR																				●									
ORBITW																●													
PART1	●	●		●					●		●		●				●		●				●	●					●
PART2			●														●												
PREVMF		●		●					●		●	●					●		●										
RESTDA																	●							●					
SRAM1				●							●	●					●		●								●		
SRAM10				●							●	●					●		●										
SRAM11												●																	
SRAM9				●			●				●	●					●		●										
SROM1				●							●	●					●		●										
SROM2											●	●					●										●		
STRATT																	●												
SUMOUT														●				●					●	●					
THISMF	●			●			●				●	●					●		●										●
VPRCI	●	●		●					●	●			●	●			●							●					
VPROC	●												●			●					●			●					

Figure 2-4. Common Block Cross - Reference

SECTION 3 - USER'S GUIDE

Program FRAPPE can be accessed and run on either the IBM 360/91 or IBM 360/75 computer. It exists as an executable LOAD module on disk. The file (member) name is K3.ZBARS.SBO18.FRAPLOAD (FRAPPE).

The program can be run with the aid of CRBE file ZB2SB.PRODMAX which contains the JCL and data for normal operation. This includes setup for IPD input tape, FRAPPE output tape, and card data. The program requires 250K of core.

INPUT DATA

The input data requires an IPD tape, an 80-character label (to be written as the header record on the output tape) card format, and NAMELIST card format.

A list of the standard input card data, with explanation, follows in the order in which they are read:

Card 1:

LABEL (I), I=1,20 FORMAT(20A4)

Eighty alphanumeric characters are read into the array LABEL. These characters may be used to describe the first file of the output tape. For example, FRAPPE TAPE NAME XR0009 DATE 5/10/77 00MS FROM IPD001, IPD002 may be input on card 1.

Card 2:

Card 2 consists of the NAMELIST INPUT. The following format is used:

Column 1	Blank
Column 2-7	&INPUT

Card 3:

Card 3 consists of variables in the namelist that are to override the default values. The following format is used:

Column 1	Blank
Column 2-80	VARIABLE=CONSTANT, VARIABLE=CONSTANT, etc.

If all the overridden variables can not be inputted on one card, then input these variables on as many more cards as necessary (in the same format as Card 3).

Last Namelist Card:

The last namelist card ends the namelist. The following format is used:

Column 1	Blank
Column 2-5	&END

The default variables for the INPUT NAMELIST are:

Variable	Description
DBGTIM = 0.0	Start time (days and fraction of days) for FRAPPE (output) tape
DENTIM = 999.0	Stop time for output tape (days and fraction of days)
DTAPLB = 10*('SCRTCH')	The input tape volume serial number of up to 10 tapes may be read in
IUNIN = 10	The FORTRAN logical unit number where the IPD input tape is read
IUNOUT = 20	The FORTRAN logical unit number where the FRAPPE output tape is written
LENGTH = 15168	The number of bytes written on the FRAPPE tape
NUMTAP = 1	The number of IPD input tapes to be read (Maximum of 10 tapes)
IFORMT = 1	The type of format read for the first record (=1ROM1, =2ROM2, =3RAM0, =4RAM1)
IQLPRD = 0	Flag for production or quicklook processing (=0 for production tape; =1 for quicklook)

Variable	Description
IFRSFG = -4	Flag for processing first record (= -4 for processing first record; =0 not the first record)
TMAG0 = 6*2.0	TMAG0 is an array of 6 values (degrees) where TMAG0(I) is the tolerence allowed for detector I (where I=1 through 6) to be parallel to magnetic field (degrees). For example, TMAG0=1, 2, 3, 4, 5, 6 means if detector 1 is within 1 degree of being parallel to the magnetic field, then it is considered to be parallel to magnetic field. Likewise, if detector 2 is within 2 degrees, detector 3 within 3 degrees, detector 4 within 4 degrees, detector 5 within 5 degrees, and detector 6 within 6 degrees, they are considered to be parallel to magnetic field.
TMAG90 = 6*2.0	TMAG90 is an array of 6 values (degrees) where TMAG90(I) is the tolerence allowed for detector I (where I=1 through 6) to be perpendicular to the magnetic field. The default of TMAG90 = 6*2.0 means all six detectors are considered to be perpendicular to the magnetic field if they are within 2 degrees of being perpendicular to magnetic field.
ELIMIT = 600.,600.,600.,600., 600.,1000.,1000.,1000.,700., 700.,700.,600.,600.,600., 500.,500.,500.	ELIMIT is an array (3,6) of electron contamination limits to describe the level of contamination of electrons on each of the six detectors. The first three values of ELIMIT are for detector 1, the second set of three values are for detector 2, etc. That is, for each set of three values there is a corresponding detector.

Variable	Description
BELECT = 1.1004, 1.12109, .80, 1.51, 1.42, .86	BELECT is an array of six values where BELECT(I) corresponds to detector I (I=1 through 6) coefficient of the equation N_e=HK_x-BELECT(1)*(HK_y-CELECT(1)) where N_e is the estimated electron rate per major frame; HK_x and HK_y are housekeeping scaler values; and CELECT is the constant dependent on the detector used.
CELECT = 276.64, 250.55, 618.91 721.08, 684.04, 978.93	CELECT is an array of six values corresponding to each of the six detectors as defined in equation 1. These are now calculated by FRAPPE.
NUFILE = 1	The file number of the IPD tape at which to start processing data

Last Cards:

After the namelist input, there are a variable number of cards in the same format as card 1, to be used as headers for subsequent files. The number of cards equals the number of MAX files that will be produced. Putting in extra cards to be safe is a good idea.

OUTPUT

The standard digital output consists of a list of the input data, Label (FRAPPE), Record Description, and a Summary Report. Also, there is a FRAPPE MAX Data Base tape. The MAX production tape contains a day's data in two files, each file contains approximately 12 hours of data. The MAX quicklook tape contains about 15 files (one file per orbit).

To obtain the file and tape required for output, one must alter the LABEL and the TAPE symbolic parameters, respectively. For example,

```
//STEP1 EXEC FRAPPE,TAPE=FR0001,LABEL=1
//GO.DATA5 DD *
  LABEL FILE 1
  &INPUT DTAPLB='XR0001', &END
//STEP2 EXEC FRAPPE, TAPE=FR0001, LABEL=2
```

```
//GO.DATA5 DD *
  LABEL FILE 2
  &INPUT DTAPLB='XR0002' , &END
```

would create two output files on tape FR0001 using IPD tape XR0001 for first file and XR0002 for the second file.

ERROR MESSAGES

I/O Errors:

FORTRAN READ errors are printed out. The message "***ERROR ON CARD INPUT" occurs if a transmission error occurs during data transfer. The message "***END OF FILE OCCURRED WHILE READING INPUT CARDS" occurs if the input data is incomplete.

FTIO FREAD errors are printed out. The message "***AN I/O ERROR ON TAPE***STOP PROCESSING**********" results if an I/O error occurs while reading the input IPD tape.

Other Errors:

Errors in attitude information are printed with the following messages:

"ATTITUDE INFORMATION NOT VALID FOR EARTH OCCULTATION"

"++++++INCORRECT VALUE OF X NO UNIT VECTOR IS FORMED"

Messages relating to an error in the number of IPD tapes allowed are printed as follows:

"NUMTAP=XXXXXXXXXX THIS IS AN ERROR"

"TEN TAPES HAVE BEEN MOUNTED **NO MORE ARE ALLOWED"

Messages relating to processing the orbit file are:

"NO MATCH IN ORBIT FILE FOR TIME OF MAJOR FRAME***"

"TIME OF LAST RECORDS (DDD. DDDD)" (Values of two times are printed.)

"TIME OF MAJOR FRAME (DDD. DDDD) THAT WAS NOT LOCATED" (Value of major frame time is then printed.)

Messages relating to the processing of Data Record #1 are:

"**PART1: INVALID VALUE FOR ROM =" (Value printed.)

"***PART1: INVALID VALUE FOR RAM =" (Value printed.)

"**PART1: RAM (ram#) follows RAM (Ram#)"
In all three cases, a 'fake RAM 0' record is written.

"**PART1: RECORD FOLLOWING (time) IS IN DUMP MODE".
A 'fake RAM ' record is written.

"**PART1: RECORD FOLLOWING (time) IS A FAKE RAM0."
The record after the time indicated has memory format -3,0.

"**PART1: MAJOR FRAME WITH TIME (time) HAS FORMAT -3,0 DUE TO BAD FORMAT OR ZERO ATTITUDE DATA." Record with time indicated is a 'fake RAM0' record.

Messages relating to the processing of data record #2 are:
"INVALID VALUES FOR MAGNETIC FIELD VECTOR COMPONENTS. DAY, SEC (time), x,y COMP. (x,y components)." The magnetic field flag is set to bad and processing continues.

Message relating to processing an IPD record is:
"BEGIN TIME (DDD.DDD) (time) IS GREATER THAN CURRENT TIME (time) **** SKIP PROCESSING THIS RECORD."

"GAP IN DATA MORE THAN 41 SECONDS BETWEEN PREVIOUS AND CURRENT MAJOR FRAME. CURRENT TIME = (time)

PREVIOUS TIME = (time)." If the gap is more than 10 major frames long a new file is started. If not, 'fake RAM0' records are written to fill up the gap.

"INVALID TYPE OF DATA ON RECORD" (Value of HTYPE)

The record processing determines whether the record is one of the following according to the value of HTYPE:

HTYPE = 1 means LABEL Record

HTYPE = 2 means ORBIT Record

HTYPE = 3 means DATA RECORD #1

HTYPE = 4 means DATA RECORD #2

A sample of the JCL for a run is given in Table 1.

TABLE L

```
//FRAPPE proc label = 1, tape = XR0250
//GO exec PGM=FRAPPE, region=250K
//STEPLIB  DD DSN=K3.ZBARS.SB018.FRAPLOAD,DISP=SHR
//GO.FT05F001  DD  DDNAME=DATA5
//GO.FT06F001  DD  SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,
      BLKSIZE=7265)
//GO.SYSPRINT  DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,
      BLKSIZE=7265)
//GO.SYSUDUMP  DD  SYSOUT=A,SPACE=(CYL,(1,1) ),
//   DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//*  IPD tape in on logical unit 10(input tape)
//GO.FT10F001  DD  disp=(old,keep),label=(1,BLP),unit=1600,,defer),
//    DCB=(RECFM=F,LRECL=6444,BLKSIZE=6444,DEN=3),
// VOL=(private,retain,SER=IPD001),DSN=ZBHED.IPD.tape
//*  FRAPPE (MAX)  tape reformatted output tape
//GO.FT20F001  DD DISP=(old,keep),label=(&label,BLP),unit=1600,
//   DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//   VOL=(private,retain,SER=&tape),DSN=ZBHED.FRAPPE.TAPE
//*Orbit file use to interpolate orbit records to major frame time
//GO.FT30F001  DD unit-2314,DISP=(new,delete),DSN=&&orbit,
//    DCB=(RECFM=VBS,LRECL=124,BLKSIZE=6204,BUFNO=1),
//    Space=(CYL,(4,1),RLSE)
//PEND PEND
//STEP1 EXEC FRAPPE,LABEL=1,tape=XR0250
//GO.DATA5  DD  *
 FRAPPE tape name XR0250 a day 226 using IPD tape  XR0208,XR0209
&INPUT
DTAPLB='XR0208','XR0209',NUMTAP=2,IQLPRD=O,
&END
```

Second file header tape XR0250 day 226 using tape XR0208,XR0290

Third file header tape XR0250 day 226 using tape XR0208,XR0290

Fourth File header tape XR0250 day 226 using tape XR0208,XR0209

Fifth file header tape XR0250 day 226 using tape XR0208,XR0209

APPENDIX A - STANDARD RAM MEMORY FORMAT

Tables A-1, A-2, and A-3 display summaries of the standard RAM's that are in use at present - RAM 1, RAM 9, and RAM 10. The meaning of the codes used is as follows:

FXDY	Function-X, DPU-Y
FO	Direct PHA readout
F1	Calibration event readout
F2	Housekeeping scalers
F3	Temporal readout
F4	Discovery scaler LSB
F5	Discovery scaler MSB
F6	PHA LSB readout
F7	PHA MSB readout
DSM	Digital status
ASM	Analog status
D0	LED 1
D1	LED 2
D2	HED 1
D3	HED 2
D4	MED
D5	HED 3

Table A-1 RAM1 Format Summary

Minor Frame Word # odd cols.	even cols.	Minor	Frame	Minor	Frame	Minor	Frame	Minor	Frame
6	134	DSM	F1D0	F2D0	F2D3	F5D0	F5D3	F5D0	F5D3
9	137	DSM	1	1	4	1	4	F1D3	F5D4
13	141	ASM	2	2	5	2	5	F1D4	F1D5
22	150	F3D0	F3D0	F3D0	F3D0	F3D0	F3D0	F3D0	F3D0
25	153	1	1	1	1	1	1	1	1
29	157	2	2	2	2	2	2	2	2
38	166	3	3	3	3	3	3	3	3
41	169	4	4	4	4	4	4	4	4
45	173	5	5	5	5	5	5	5	5
54	182	0	0	0	0	0	0	0	0
57	185	1	1	1	1	1	1	1	1
61	189	2	2	2	2	2	2	2	2
70	198	3	3	3	3	3	3	3	3
73	201	4	4	4	4	4	4	4	4
77	205	5	5	5	5	5	5	5	5
86	214	F6D0	F6D3	F6D0	F6D3	F6D0	F6D3	F6D0	F6D3
89	217	1	4	1	4	1	4	1	4
93	221	2	5	2	5	2	5	2	5
102	230	F4D0	F4D0	F4D0	F4D0	F4D0	F4D0	F4D0	F4D0
105	233	1	1	1	1	1	1	1	1
109	237	2	2	2	2	2	2	2	2
118	246	3	3	3	3	3	3	3	3
121	249	4	4	4	4	4	4	4	4
125	253	5	5	5	5	5	5	5	5

Table A-2 RAM9 Format Summary

Minor Frame Odd Cols.	Word # Even Cols.	Minor	Frame	Minor	Frame	Minor	Frame	Minor	Frame
6	134	DSM	F7D3	F7D3	F2D3	F1D5	F5D3	F5D5	F5D3
9	137	DSM	3	F7D3	4	F5D2	4	F1D3	4
13	141	ASM	F1D2	2	5	2	5	F1D4	F1D5
22	150	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2
25	153	4	4	4	4	4	4	4	4
29	157	5	5	5	5	5	5	5	5
38	166	F6D2	F6D2	F6D2	F6D2	F6D2	F6D2	F6D2	F6D2
41	169	2	2	2	2	2	2	2	2
45	173	3	3	3	3	3	3	3	3
54	182	3	3	3	3	3	3	3	3
57	185	4	4	4	4	4	4	4	4
61	189	4	4	4	4	4	4	4	4
70	198	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2	F3D2
73	201	4	4	4	4	4	4	4	4
77	205	5	5	5	5	5	5	5	5
86	214	F6D5	F6D5	F6D5	F6D5	F6D5	F6D5	F6D5	F6D5
89	217	5	5	5	5	5	5	5	5
93	221	F7D2	F7D4	F7D2	F7D4	F7D2	F7D4	F7D2	F7D4
102	230	5	5	5	5	5	5	5	5
105	233	5	5	5	5	5	5	5	5
109	237	F4D2	F4D2	F4D2	F4D2	F4D2	F4D2	F4D2	F4D2
118	246	3	3	3	3	3	3	3	3
121	249	4	4	4	4	4	4	4	4
125	253	5	5	5	5	5	5	5	5

Table A-3 RAM10 Format Summary

Minor Frame Odd Cols.	Word # Even Cols.	Minor	Frame	Minor	Frame	Minor	Frame	Minor	Frame
6	134	DSM	F1D0	F2D0	F2D3	F5D0	F5D3	F5D0	F5D3
9	137	DSM	1	1	4	1	4	F1D3	4
13	141	ASM	2	2	5	2	5	4	F1D5
22	150	F6D0							
25	153	F3D1							
29	157	F6D0							
38	166	F3D3							
41	169	F6D2							
45	173	2							
54	182	4							
57	185	F3D1							
61	189	F6D4							
70	198	F3D3							
73	201	F6D5							
77	205	5							
86	214	F7D0	F6D3	F7D0	F6D3	F7D0	F6D3	F7D0	F6D3
89	217	F6D1	F7D4	F6D1	F7D4	F6D1	F7D4	F6D1	F7D4
93	221	F7D2	F7D5	F7D2	F7D5	F7D2	F7D5	F7D2	F7D5
102	230	F4D0							
105	233	1							
109	237	2							
118	246	3							
121	249	4							
125	253	5							

APPENDIX B - MAX DATA BASE FORMAT

INTRODUCTION

The MAX data base is created by reblocking IPD tape records so that all data accumulated during a major frame (40.96 seconds) is present in one physical record. This record includes information from Data Record 1, Data Record 2 and the Orbit Records of the IPD format tape. Science data is associated with the major frame during which the data was accumulated, not with telemetry time. The MAX record also contains ten flags which are the result of preliminary analysis of the data. In general, a zero flag represents the desired condition.

TAPE CHARACTERISTICS

TAPE ATTRIBUTES:

9 track 1600 bpi

FILE STRUCTURE:

Quicklook: 15-20 files per tape. Each file represents one orbit.

Production: 2 files per tape. Each file represents 12 hours of data.

RECORD FORMAT:

Fixed length unblocked.

recfm=f,blksize=15168 or recfm=fb,lrecl=15168,blksize=15168

RECORD STRUCTURE WITHIN A FILE:

Record 1: All MAX files have a 15168 byte header record with data in the first 34 bytes only. The first 80 bytes identify the IPD input tape, the MAX output tape and creation date. Bytes 81-84 contain the Quicklook/Production flag in I*4 format.

Quicklook = 1 Production = 0

Record 2: This record contains data accumulated prior to the first record on the IPD tape. Therefore, a great portion of this record is fill data.

Record 3: All MAX records have a 64 byte section at the **beginning which contains the day,** time, memory format and all flags (see Figure B-1). All MAX records, except accelerated housekeeping (RAM 0) format, follow this with a common section containing digital and analog status, attitude data, orbit data, calibration data, discovery scalers, and housekeeping scalers (see Figure B-2). All MAX records, except RAM0, follow the common section with data unique to the format in use during accumulation i.e. ROM 1, ROM 2, RAMs . (see Figure B-3). The accelerated housekeeping format (RAM 0) has the 64 byte section followed by digital and analog status (see Figure B-4).

DATA QUALITY

There are three checks made on the quality of data. A block encoder error indicates a transmission error from S/C to ground. A bit error indicates one or more bits within a minor frame has been improperly received. Fill data indicates data for that minor frame is missing. IPD fill data is a 0. When MAX is created the IPD records are checked for these errors and an overall data quality flag (HERRF) is set. This flag indicates if there was a block encoder error, bit errors or fill data anywhere in the major frame. Additionally the data within the MAX record is altered if there was a bit error or fill data in the minor frame from which it was extracted. Bit errors are indicated by making the data negative. Fill data is indicated by replacing the data with hexadecimal 'AAAA'.

COMMON BLOCK DESCRIPTION

The common block CURREC can be used to reference the MAX data base. A description of the variables follows:

mfday	I*4	day of major frame
msec	I*4	milliseconds at start of major frame
hmform	I*2	memory format in use. This field may be negative when there is fill data or bit errors in the first minor frame. 1 = ROM 1 2 = ROM 2 3 = RAM
hram	I*2	ram number. Can be negative. 0 = accelerated housekeeping 1 = RAM 1 Special case: Gaps in data and frames with attitude data missing have been given the following memory format. hmform = -3, hram = 0, herrf .ge. 4
herrf	I*2	data quality flag 2**0 = block encoder 2**1 = bit error 2**2 = fill data bit = 0 = no error, bit = 1 = error
hengf	I*2	engineering/science format flag 0 = all data in major frame is science 1 = some data is engineering format data
heoccl	I*2	earth occultation flag (not including atmosphere) 2**0 = led 1 2**1 = led 2 2**2 = hed 1

		2**3 = hed 2
		2**4 = med
		2**5 = hed 3
		bit = 0 = no occultation, bit = 1 = occult.
heocc2	I*2	earth occultation flag (incl. atmosphere)
		2**0 = led 1
		2**1 = led 2
		etc
		bit = 0 = no occultation, bit = 1 = occult.
heconf	I*2	electron contamination flag
		2**1, 2**0 = led 1 limit=600
		2**3, 2**2 = led 2 limit=600
		2**5, 2**4 = hed 1 limit=1000
		2**7, 2**6 = hed 2 limit=700
		2**9, 2**8 = med limit=600
		2**11, 2**10 = hed 3 limit=500
		bits = 00 = electron rate .le. limit
		bits = 11 = electron rate .gt. limit
hmagf	I*2	magnetic field direction flag
		2**0 = led 1
		2**1 = led 2
		etc
		0 = field is neither parallel or perpendicular to detector axis.
		1 = field parallel or perpendicular.
hvflag	I*2	high voltage flag
		2**0 = led 1
		2**1 = led 2
		etc

		0 = high voltage on and not within 2 frames of turn on. 1 = high voltage off or within 2 frames of turn on.
hsarpf	I*2	SAA/NPA anomaly flag - also sunlight flag 2**0 = SAA/NPA bit = 0 no SAA/NPA bit = 1 SAA/NPA 2**1 = sunlight bit = 0 no sunlight bit = 1 sunlight
hjetps	I*2	number of thruster firings during major frame
hvst	I*2	high voltage stability flag 2**0 = led 1 2**1 = led 2 etc 0 = stable 1 = unstable
ispare(4)	I*4	spare
imusec(2)	I*4	microseconds of major frame
hmfcnt	I*2	major frame counter
qcstat(6)	L*1	DPU status for 6 detectors
qdstat(64)	L*1	digital status
qastat(32)	L*1	analog status
qdform(128)	L*1	engineering/science format per minor frame 0 = engineering 1 = science
qerr1(128)	L*1	flags from data record 1 per minor frame
qerr2(128)	L*1	flags from data record 2 per minor frame
iclock(128)	I*4	S/C clock per minor frame

spra(32)	R*4	right ascension of spin axis(rad. 1950)
spdec(32)	R*4	declination of spin axis(rad. 1950)
yra(32)	R*4	right ascension of Y axis(rad. 1950)
ydec(32)	R*4	declination of Y axis(rad. 1950)
splon(32)	R*4	galactic longitude of spin axis(rad. 1950)
splat(32)	R*4	galactic latitude of spin axis(rad. 1950)
ylon(32)	R*4	galactic longitude of Y axis (rad. 1950)
ylat(32)	R*4	galactic latitude of Y axis(rad. 1950)
gyro(32,3)	R*4	gyro drift X, Y, Z (rad./sec.)
zerr(32)	R*4	probable error for Z axis (rad.)
yerr(32)	R*4	probable error for Y axis (rad.)
att(32)	R*4	attitude flag field
hbus(4)	I*2	essential and non-essential bus each bit right justified in halfword
heaa2	I*2	EAA2 bit right justified in halfword
ha2stb	I*2	standby heater bit right just. in halfword
ht1	I*2	interface one temperature(C)
ht2	I*2	interface two temperature(C)
quat(24)	L*1	quaternions
b(3)	R*4	magnetic field vector in S/C coordinates X, Y, Z
phiear	R*4	angle phi (rad.)
thear	R*4	angle theta (rad.) theta and phi define vector from S/C to center of earth in S/C coordinates.
el	R*4	earth horizon angle E1
e2	R*4	earth horizon angle E2
itype	I*4	type of data indicator from orbit record see IPD orbit record description for values

ionum	I*4	orbit number
odata(25)	R*4	orbit data interpolated for this major frame, see Figure B-2 for array layout
hcal(32,6)	I*2	calibration data for 6 detectors RAM 1 has 32 readouts per major frame, ROM 1 and ROM 2 have 16 readouts. (last 16 readouts/det. are set to hex 'AAAA')
ihk(10,6)	I*4	housekeeping scalers 10 scalers/det.
hdsc(5,8,8,6)	I*2	discovery scalers 5 = four-1.28 sec., and one-5.12 sec. readouts 8 = readouts per major frame 8 = scalers 6 = detectors
hphtmp(3840)	I*2	data unique to memory format in use during accumulation ROM 1 = pha(128,5,6) ROM 2 = temporal(40,16,6) RAM 1 = temporal(512,6), pha(128,6)

For RAM formats numbered greater than 1, the usage of this block varies considerably. For the semi-standard formats (RAM 2-8), the telemetry words in the PHA/TEMPORAL locations can be set arbitrarily. These words are extracted, changed to two-byte words, and placed in the same sequence in HPHTMP as for RAM 1. All other telemetry words are unpacked in the same way as for the RAM 1 format.

For the non-standard format (RAM 11-15), the raw telemetry data is transferred to a one-byte array starting at the location of the first byte of HPHTMP. The locations used in RAM 1 for Digital and Analog status, Housekeeping scalers, calibration data and Discovery scalers, are unpacked and placed in the MAX record in the same way as for RAM 1, but only the status and Housekeeping scaler words will always be retained in the non-standard formats.

The other two standard formats, RAM 9 and RAM 10, are unpacked in detail. The descriptions of these is as follows:

RAM 9 is a special format created following the demise of the LED's in normal operations. As a result,

(a) the LED 1 and LED 2 locations in HDSC and IHK are all fill data

(b) the LED 1 locations in HCAL contain 32 of the 64 words of HED 3 calibration data

(c) the LED 2 locations in HCAL contain fill data

(d) the HPHTMP block is divided into four equal blocks for detectors HED 1, HED 2, MED, and HED 3 respectively. Each detector block has the form

HPHA (128,5), QTMP (512), QDUM (128)

where HPHA is I*2, QTMP and QDUM are I*1, and where

1) for HED 1 and MED, HPHA contains four 128 channel 10.24 second LSB accumulations, and the 40.96 second MSB-LSB sum. QTMP contains multiscaler data, and QDUM contains fill data.

2) for HED 3, HPHA contains four 128 channel 10.24 second MSB-LSB accumulations and the 40.96 second sum of these. QTMP contains the multiscaler data, and QDUM contains fill data.

3) for HED 2, HPHA contains four 128 channel 10.24 second LSB accumulations, and the 40.96 second MSB-LSB sum. Both QTMP and QDUM contain fill data.

For the RAM 10 format, only the HPHTMP array is changed from RAM 1. This array has equal blocks for each of the six detectors, i.e., the array has the form HPHTMP (640, 6), and the 640 two-byte numbers for each detector contain the following:

1) For LED 2 and HED 2, the first 512 words are multiscaler data and the last 128 words contain a 128 channel, 40.96 second LSB accumulation of PHA data, i.e. HPHTMP (640) HTMP (512), HPHA (128)

2) For LED 1, HED 1, MED and HED 3, the block contains the four 128 channel, 10.24 second LSB accumulations and the 40.96 second LSB-MSB sum of PHA data, i.e. (HPHTMP (640) HPHA (128, 5)

CATALOG DESCRIPTION

A catalog has been created for the MAX Quicklook tapes listing the tape number, file number, orbit and time range of the data.

Tape #	File #	Orbit #	Start Day	Start Time	End Day	End Time

A similar catalog will be created for production tapes when applicable. When a MAX tape has been brought back for storage, the tape number will be blank.

The MAX catalog can be accessed from TSO or CRBE.

MAX Quicklook:

From CRBE: b d=ZBFLL,HEAOTAPE. LIST (QLCATLG)
From TSO: qed 'ZBFLL,HEAOTAPE. LIST (QLCATLG)'

MAX Production:

From CRBE: b d=ZB2SB.HEAOTAPE. LIST (PRODCTLG)
From TSO: qued 'ZB2SB.HEAOTAPE. LIST (PRODCTLG)

An up to date listing is also kept in the HEAO data room (250).

FIGURE B-1

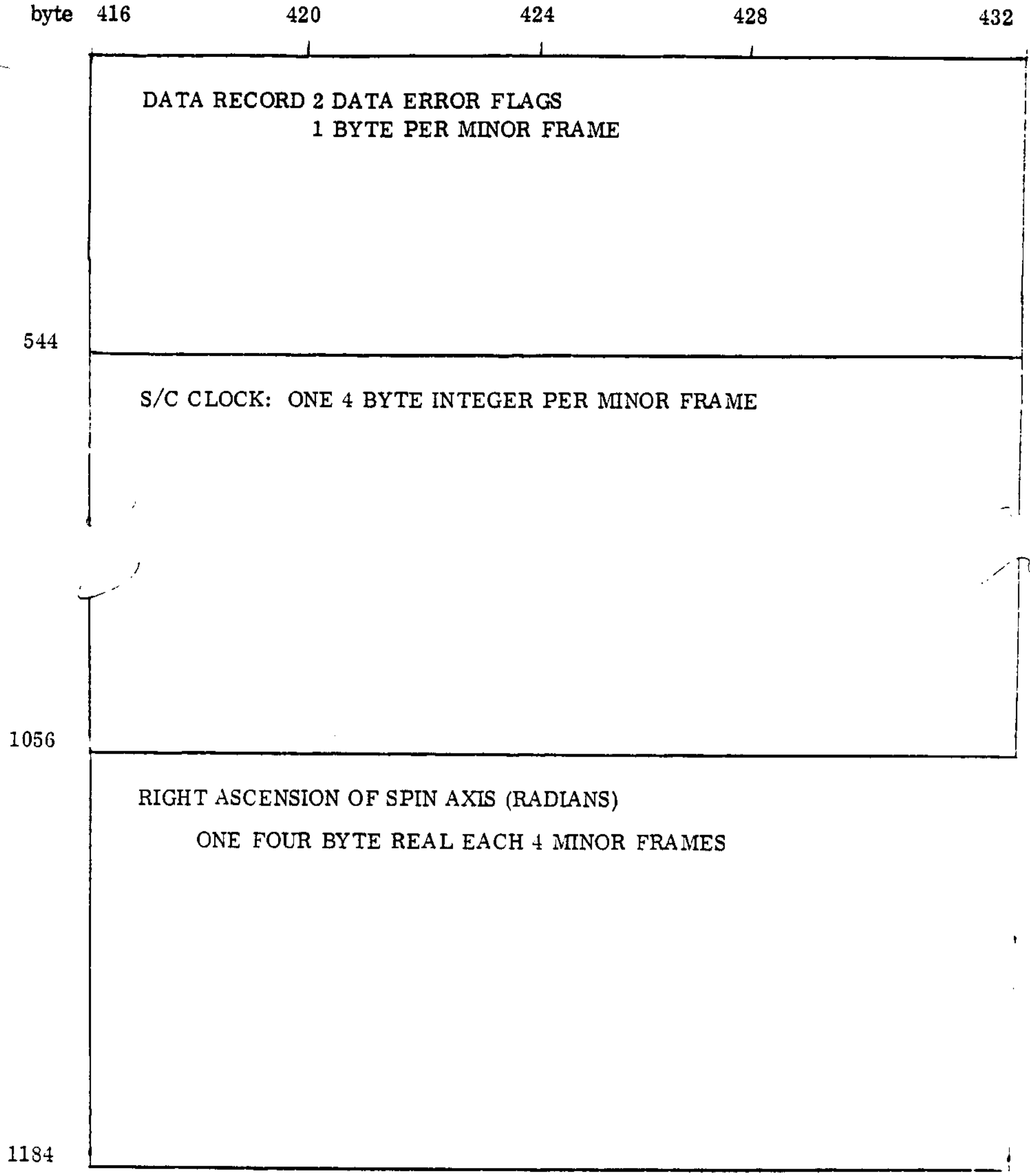
byte 0		4		8		12	16
Day of Data		Milliseconds and Day		Memory Format	RAM #	Major Frame Data Error Flag	Major Frame Eng. Format Flag
Earth Occult. I Flag	Earth Occult. II Flag	Electron Contamin. Flag	Magnetic Field Flag	High Volt. Flag	SAA/NPA Flag	Jet Firing Flag	High Volt. Flag
SPARE							
Microseconds of Day				Major Frame Counter	DPU Command Status Led 1, Led 2, Hed 1, Hed 2, Med 1, Hed 3		
64							

END OF 64-BYTE SECTION

FIGURE B-2

byte	64	68	72	76	80

64	DIGITAL STATUS: 64 BYTES IN TELEMETRY ORDER
128	ANALOG STATUS: 32 BYTES IN TELEMETRY ORDER
160	DATA FORMAT FLAGS: 1 BYTE FOR EACH MINOR FRAME 0 = ENGINEERING FORMAT 1 = SCIENCE FORMAT
238	DATA RECORD 1 DATA ERROR FLAGS 1 BYTE PER MINOR FRAME
416	


byte 416
420
424
428
432
DATA RECORD 2 DATA ERROR FLAGS
1 BYTE PER MINOR FRAME
544
S/C CLOCK: ONE 4 BYTE INTEGER PER MINOR FRAME
1056
RIGHT ASCENSION OF SPIN AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES
1184

byte 1184 1188 1192 1196 1200

DECLINATION OF SPIN AXIS. (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1312

RIGHT ASCENSION OF Y AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1440

DECLINATION OF Y AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1568

byte 1568 1572 1576 1580 1584

GALACTIC LONGITUDE OF SPIN AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1696

GALACTIC LATITUDE OF SPIN AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1824

GALACTIC LONGITUDE OF Y AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

1952

byte 1952 1956 1960 1964 1968

GALACTIC LATITUDE OF Y AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2080

GYRO DRIFT X_b (RADIANS/SEC)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2208

GYRO DRIFT Y_b (RADIANS/SEC)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2336

byte 2336 2340 2344 2348 2352

GYRO DRIFT Z_b (RADIANS/SEC)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2464

PROBABLE ERROR FOR Z AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2592

PROBABLE ERROR FOR Y AXIS (RADIANS)
ONE FOUR BYTE REAL EACH 4 MINOR FRAMES

2720

byte 2720 | 2724 | 2728 | 2732 | 2736

ATTITUDE FLAG FIELD

FOUR BYTES EACH 4 MINOR FRAMES

2848

ESSBUS1 (3)	ESSBUS2 (4)	NESSBUS1 (5)	NESSBUS2 (6)	EAA2	A2 STB HTR	A2 - IT (°C)	A2 - 2T (°C)

QUATERNIONS

1 BYTE EACH

		B X Magnetic Field Comp. θEarth (Rad.)	B Y Magnetic Field Comp. E1 (Radians)
B Z Magnetic Field Comp.	ϕEarth (Radians)		
E2 (Rad.)	Orbital Data Type Flag	Orbital Number	Sat. Posn X (Km)
Sat. Posn. Y (Km)	Sat. Posn Z (Km)	Sat. Vel. X (Km/sec)	Sat. Vel. Y (Km/sec)
Sat. Vel. Z (Km/sec)	Geod. Long. (deg.)	Goed. Lat. (deg.)	Altitude (Km)
Lunar Posn. Y (Km)	Lunar Posn. Z (Km)	McIlwain Par. Earth Rad.)	Magnetic Field Str. B (Gauss)
Magnetic Unit Vec. R	Magnetic Field Unit Vec., θ	Magnetic Field Unit Vec., ϕ	Magnetic Field R.A. (Rad.)
Magnetic Field Decl. (Rad.)	Solar Time (deg)	Sun-Shadow Flag	Subsat-Earth Horizon Angle

3024

CALIBRATION EVENTS: LED 1

ONE TWO BYTE INTEGER EACH EVENT
LEAST SIGNIFICANT 2 BITS ARE ID BITS

3088

byte 3088 3092 3096 3100 3104

CALIBRATION EVENTS: LED 2

3152

CALIBRATION EVENTS: HED 1

3216

CALIBRATION EVENTS: HED 2

3280

CALIBRATION EVENTS: MED

3344

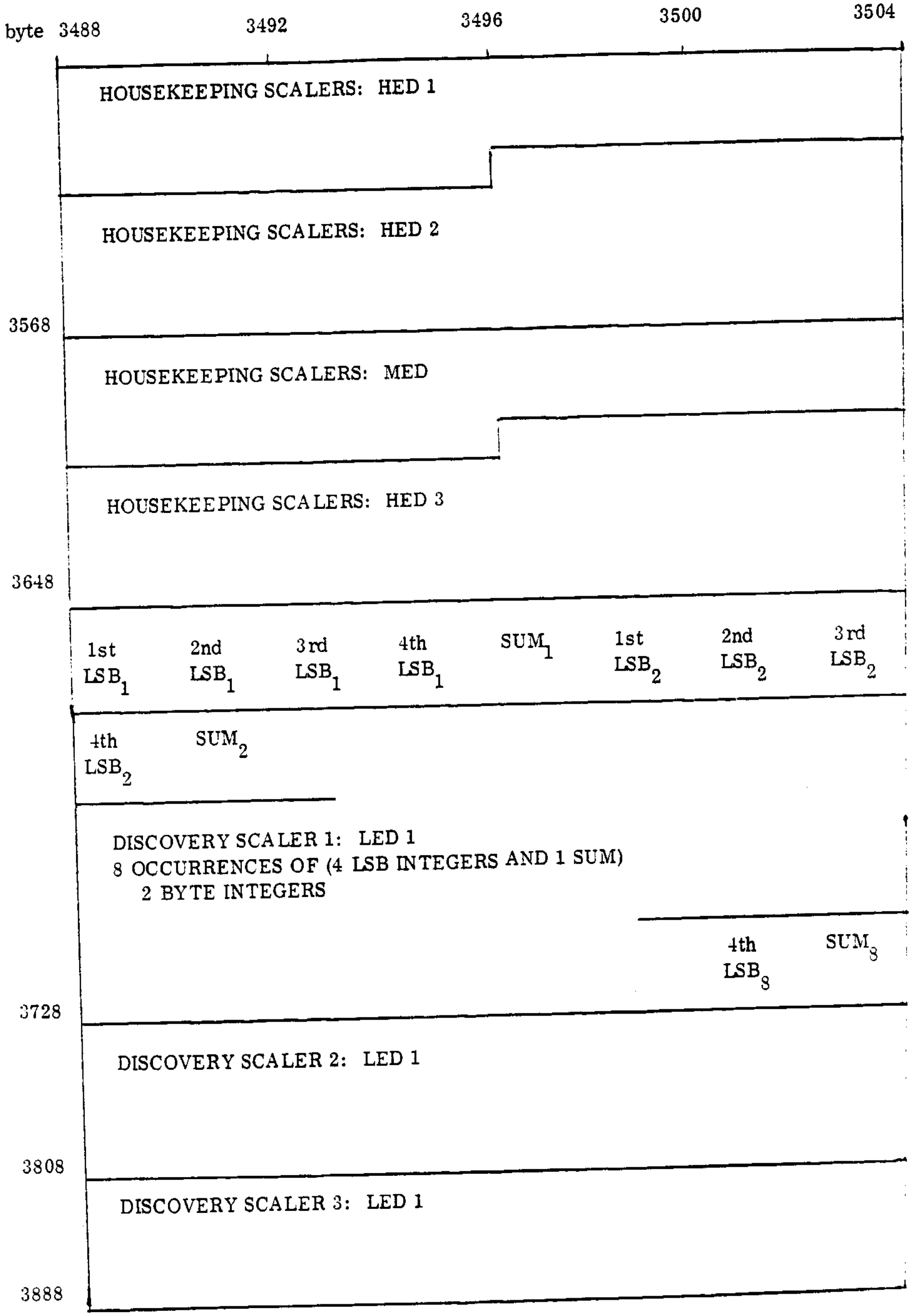
CALIBRATION EVENTS: HED 3

3408

HOUSEKEEPING SCALERS: LED 1
ONE FOUR BYTE INTEGER EACH OF 10 SCALERS

HOUSEKEEPING SCALERS: LED 2

3488


byte 3488
3492
3496
3500
3504
HOUSEKEEPING SCALERS: HED 1
HOUSEKEEPING SCALERS: HED 2
3568
HOUSEKEEPING SCALERS: MED
HOUSEKEEPING SCALERS: HED 3
3648
1st LSB_1
2nd LSB_1
3rd LSB_1
4th LSB_1
SUM_1
1st LSB_2
2nd LSB_2
3rd LSB_2
4th LSB_2
SUM_2
DISCOVERY SCALER 1: LED 1
8 OCCURRENCES OF (4 LSB INTEGERS AND 1 SUM)
2 BYTE INTEGERS
4th LSB_8
SUM_8
3728
DISCOVERY SCALER 2: LED 1
3808
DISCOVERY SCALER 3: LED 1
3888

byte 3888	3892	3896	3900	3904

Byte	
3888	DISCOVERY SCALER 4: LED 1
3968	CYCLE OVER 8 DISCOVERY SCALERS AND 6 DETECTORS
7328	DISCOVERY SCALER 7: HED 3
7408	DISCOVERY SCALER 8: HED 3
7488	

END OF COMMON SECTION

FIGURE B-3

Format ROM 1

byte 7488 7492 7496 7500 7504

Ch. 01 LSB | Ch. 02 LSB | Ch. 03 LSB | Ch. 04 LSB | Ch. 05 LSB

PHA DATA: LED 1 (1 ST LSB OCCURENCE)

ONE 2-BYTE INTEGER FOR EACH PULSE
HEIGHT HISTOGRAM PACKED CHANNEL

Ch. 127 LSB | Ch. 128 LSB

7744

PHA DATA: LED 1 (2 ND LSB OCCURRENCE)

7872

Cont.

byte 7872 7876 7880 7884 7888

Cont.

8000

PHA DATA: LED 1 (3 RD LSB OCCURRENCE)

8256

byte 8256 8260 8264 8268 8272

PHA DATA: LED 1 (4 TH LSB OCCURRENCE)

8512

PHA DATA: LED 1 (SUMMARY HISTOGRAM)

8640

cont.

ROM 1

byte 8640 8644 8648 8652 8656

cont.

8768

PHA DATA: LED 2 (1 ST LSB OCCURRENCE)

CYCLE OVER DETECTORS

15168

END OF MAX RECORD

Format ROM 2

byte 7488 7492 7496 7500 7504

TEMPORAL DATA: LED 1

MODES 1 AND 3 - 640 EVENTS

MODE 2 - 512 EVENTS

(16 TWELVE BIT, 16 EIGHT BIT, 8 FILL
REPEATED 16 TIMES - DETECTORS 1-3)

(16 EIGHT BIT, 16 TWELVE BIT, 8 FILL
REPEATED 16 TIMES - DETECTORS 4-6)

8768

TEMPORAL DATAL LED 2

CYCLE OVER DETECTORS

15168

END OF MAX RECORD

byte 7488 | 7492 | 7496 | 7500 | 7504

TEMPORAL DATA: LED 1 (512 EVENTS

ONE 2-BYTE INTEGER FOR EACH TEMPORAL READOUT

8512

TEMPORAL DATA: LED 2 (512 EVENTS)

CYCLE OVER DETECTORS

13632

RAM 1

byte 13632 13636 13640 13644 13648

Ch. 01 Ch. 02 Ch. 03 Ch. 04

PHA DATA: LED 1

ONE 2-BYTE INTEGER FOR EACH CHANNEL

Ch. 127 Ch. 128

13888

PHA DATA: LED 2

CYCLE OVER DETECTORS

15168

END OF MAX RECORD

Format RAM 9

byte 7488 7492 7496 7500 7504

Ch. 1 LSB | Ch. 2 LSB | Ch. 3 LSB | Ch. 4 LSB

PHA DATA: HED1 (1ST LSB OCCURRENCE)

ONE 2-BYTE INTEGER FOR EACH PULSE

HEIGHT HISTOGRAM PACKED CHANNEL

128 CHANNELS

Ch. 127 LSB | Ch. 128 LSB

7744 Ch. 1 LSB | Ch. 2 LSB

PHA DATA: HEDI (2ND LSB OCCURRENCE)

128 CHANNELS

Ch. 128 LSB

8000 Ch. 1 LSB

PHA DATA: HED1 (3RD LSB OCCURRENCE)

128 CHANNELS

Ch. 128 LSB

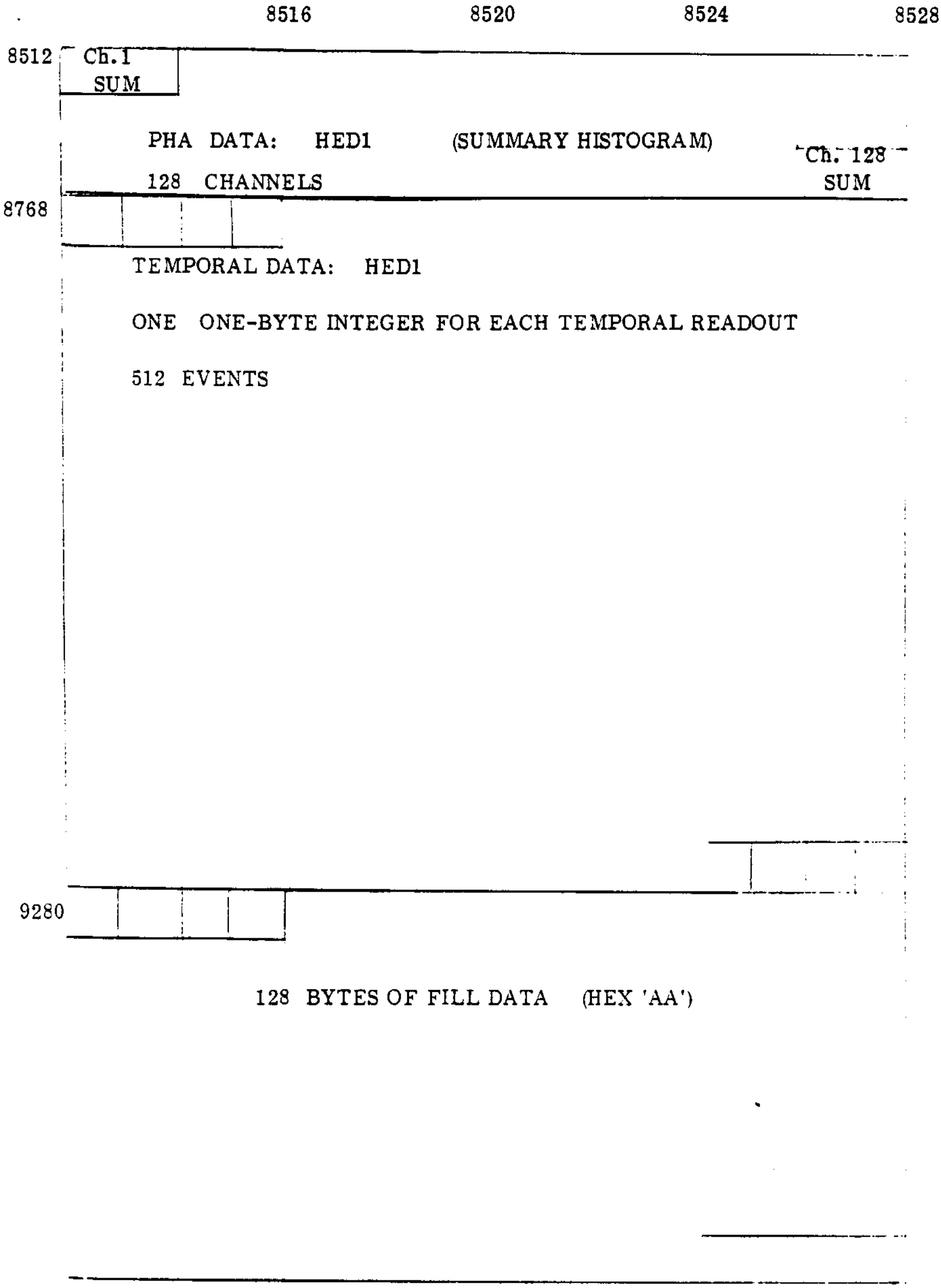
8256 Ch. 1 LSB

PHA DATA: HED1 (4TH LSB OCCURRENCE)

128 CHANNELS

Ch. 128 LSB

RAM 9


8516
8520
8524
8528
8512
Ch.1
SUM
PHA DATA: HED1 (SUMMARY HISTOGRAM)
128 CHANNELS
Ch. 128
SUM
8768
TEMPORAL DATA: HED1
ONE ONE-BYTE INTEGER FOR EACH TEMPORAL READOUT
512 EVENTS
9280
128 BYTES OF FILL DATA (HEX 'AA')

RAM 9

			9412	9416	9420	9424
9408	Ch. 1 LSB	Ch. 2 LSB				

PHA DATA: HED2 (1ST LSB OCCURRENCE)

128 CHANNELS

Ch. 128 LSB

9664 Ch. 1 LSB

PHA DATA: HED2 (2ND LSB OCCURRENCE)

Ch. 128 LSB

9920 Ch. 1 LSB

PHA DATA: HED2 (3RD LSB OCCURRENCE)

Ch. 128 LSB

10176 Ch. 1 LSB

PHA DATA: HED2 (4TH LSB OCCURRENCE)

Ch. 128 LSB

10432 Ch. 1 SUM

PHA DATA: HED2 (SUMMARY HISTOGRAM)

Ch. 128 SUM

10688

640 BYTES OF FILL DATA (HEX 'AA')

RAM 9

11332 11336 11340 11344

11328 Ch. 1 LSB

PHA DATA: MED (1ST LSB OCCURRENCE)

128 CHANNELS

Ch. 128 LSB

11584 Ch. 1 LSB

PHA DATA: MED (2ND LSB OCCURRENCE)

Ch. 128 LSB

11840 Ch. 1 LSB

PHA DATA: MED (3RD LSB OCCURRENCE)

Ch. 128 LSB

12096 Ch. 1 LSB

PHA DATA: MED (4TH LSB OCCURRENCE)

Ch. 128 LSB

12352 Ch. 1 SUM

PHA DATA: MED (SUMMARY HISTOGRAM)

Ch. 128 SUM

12608

TEMPORAL DATA: MED

512 EVENTS

13120

128 BYTES OF FILL DATA (HEX 'AA')

RAM 9

		13252	13256	13260	13264
13248	Ch. 1 LSB-MSB				

PHA DATA: HED3 (1ST LSB-MSB OCCURRENCE)

128 CHANNELS

Ch. 128
LSB-MSB

13504 Ch. 1
LSB-MSB

PHA DATA: HED3 (2ND LSB-MSB OCCURRENCE)

Ch. 128
LSB-MSB

13760 Ch. 1
LSB-MSB

PHA DATA: HED3 (3RD LSB-MSB OCCURRENCE)

Ch. 128
LSB-MSB

14016 Ch. 1
LSB-MSB

PHA DATA: HED3 (4TH LSB-MSB OCCURRENCE)

Ch. 128
LSB-MSB

14272 Ch. 1
SUM

PHA DATA: HED3 (SUMMARY HISTOGRAM)

Ch. 128
SUM

14528

TEMPORAL DATA: HED3

512 EVENTS

15040

128 BYTES OF FILL DATA (HEX 'AA')

END OF MAX RECORD

Format RAM 10

7492 7496 7500 7504

byte 7488 Ch. 1 LSB

PHA DATA: LED1 (1ST LSB OCCURRENCE)

Ch. 128 LSB

7744 Ch. 1 LSB

PHA DATA: LED1 (2ND LSB OCCURRENCE)

Ch. 128 LSB

8000 Ch. 1 LSB

PHA DATA: LED1 (3RD LSB OCCURRENCE)

Ch. 128 LSB

8256 Ch. 1 LSB

PHA DATA: LED1 (4TH LSB OCCURRENCE)

Ch. 128 LSB

8512 Ch. 1 SUM

PHA DATA: LED1 (SUMMARY HISTOGRAM)

Ch. 128 SUM

8768

TEMPORAL DATA: LED2

512 EVENTS (ONE TWO-BYTE WORD EACH)

9792 Ch. 1 LSB

PHA DATA: LED2 (40.96 SEC. LSB)

RAM 10

10052 10056 10060 10064

10048 Ch. 1
LSB, Occ 1

PHA DATA: HED 1 (FOUR LSB OCCURRENCES AND ONE SUM)

128 CHANNELS

Ch. 128
SUM

11328

TEMPORAL DATA: HED2

512 EVENTS (ONE TWO-BYTE WORD EACH)

11352 Ch. 1
LSB

PHA DATA: HED2 (40.96 SEC. LSB)

Ch. 128
LSB

11608 Ch. 1
LSB, Occ 1

PHA DATA: MED (FOUR LSB OCCURRENCES AND ONE SUM)

128 CHANNELS

Ch. 128
SUM

12888 Ch. 1
LSB, Occ 1

PHA DATA: HED3 (FOUR LSB OCCURRENCES AND ONE SUM)

128 CHANNELS

Ch. 128
SUM

END OF MAX RECORD

byte
7488

TELEMETRY STREAM DATA AS IT APPEARS IN DATA RECORD #1, BUT EXCLUDING THE CLOCK AND FLAG BYTES. 192 WORDS PER SEQUENCE, 32 SEQUENCES = 6144 ONE-BYTE WORDS

13632

1536 BYTES OF FILL DATA (HEX 'AA')

END OF MAX RECORD

Figure B-4

Format RAM 0

byte 64 68 72 76 80

DIGITAL STATUS: 64 BYTES IN TELEMETRY ORDER

INCLUDING STATUS FOR DET 1-3

128

ANALOG STATUS:

1 ST HALF OF DATA

256

DIGITAL STATUS:

INCLUDING STATUS FOR DET 4-6

320

ANALOG STATUS:

2 ND HALF OF DATA

448

byte 448 452 456 460 464

DIGITAL STATUS

512

ANALOG STATUS

CYCLE FOR 32 TOTAL DIGITAL/ANALOG

6208

DATA ERROR FLAG (DATA RECORD 1)

1 BYTE/MINOR FRAME

6336

DATA FORMAT FLAGS: 1 BYTE FOR EACH MINOR FRAME

0 = ENGINEERING FORMAT
1 = SCIENCE FORMAT

6464

SPARE

15168

END OF MAX RECORD

D10/211

654–665

654

RECORD 2 OF FILE 1
LENGTH = 15168 BYTES

10/28/78–11/20/78

0000028E 00889618 00030009 00000000 00000000 03C00000 00030002 01050000 003C002C 003D0000
0000AAAA AAAAAAAA 00000002 158A507C 00270000 B1B1B1B3 27036E57 2F2F541C 642C0000 700010D5
B001693A 15515A00 0C500000 0000CB00 000C8800 0000D000 000000CB 0C0000E8 000000D0 00000000
CB0C020C 88000000 AF000000 A5000000 B7960049 A9960048 B696009C A7930038 7D7B0200 937CE86F
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 06ECB600 06ECB601 06ECB602 06ECB603
06ECB604 06ECB605 06ECB606 06ECB607 06ECB608 06ECB609 06ECB60A 06ECB60B 06ECB60C 06ECB60D
06ECB60E 06ECB60F 06ECB610 06ECB611 06ECB612 06ECB613 06ECB614 06ECB615 06ECB616 06ECB617
06ECB618 06ECB619 06ECB61A 06ECB61B 06ECB61C 06ECB61D 06ECB61E 06ECB61F 06ECB620 06ECB621
06ECB622 06ECB623 06ECB624 06ECB625 06ECB626 06ECB627 06ECB628 06ECB629 06ECB62A 06ECB62B
06ECB62C 06ECB62D 06ECB62E 06ECB62F 06ECB630 06ECB631 06ECB632 06ECB633 06ECB634 06ECB635
06ECB636 06ECB637 06ECB638 06ECB639 06ECB63A 06ECB63B 06ECB63C 06ECB63D 06ECB63E 06ECB63F
06ECB640 06ECB641 06ECB642 06ECB643 06ECB644 06ECB645 06ECB646 06ECB647 06ECB648 06ECB649
06ECB64A 06ECB64B 06ECB64C 06ECB64D 06ECB64E 06ECB64F 06ECB650 06ECB651 06ECB652 06ECB653
06ECB654 06ECB655 06ECB656 06ECB657 06ECB658 06ECB659 06ECB65A 06ECB65B 06ECB65C 06ECB65D
06ECB65E 06ECB65F 06ECB660 06ECB661 06ECB662 06ECB663 06ECB664 06ECB665 06ECB666 06ECB667
06ECB668 06ECB669 06ECB66A 06ECB66B 06ECB66C 06ECB66D 06ECB66E 06ECB66F 06ECB670 06ECB671
06ECB672 06ECB673 06ECB674 06ECB675 06ECB676 06ECB677 06ECB678 06ECB679 06ECB67A 06ECB67B
06ECB67C 06ECB67D 06ECB67E 06ECB67F 4137FC05 4137FC05 4137FC05 4137FC05 4137FC04 4137FC03
4137FC04 4137FC04 4137FC1C 4137FC3C 4137FC5D 4137FC7E 4137FC9F 4137FCBF 4137FCE2 4137FD00
4137FD20 4137FD40 4137FD60 4137FD7F 4137FD9E 4137FDBC 4137FDDB 4137FDF8 4137FE16 4137FE33
4137FE50 4137FE6D 4137FE89 4137FEA5 4137FEC1 4137FEE5 C0287790 C02878EF C0287A73 C0287BBA
C0287D43 C0287E99 C0288027 C02881A6 C0288045 C0287E30 C0287BCE C0287958 C02876F4 C0287488
C028720B C0286FAB C0286D44 C0286AD1 C0286860 C02865F3 C0286393 C0286127 C0285EBA C0285C5F
C02859F3 C0285799 C0285533 C02852D6 C028506A C0284E13 C0284BB6 C0284865 414CD71F 414CCE0D
414CC4DE 414CBB93 414CB22C 414CA8AC 414C9F09 414C954A 414C8BC6 414C8243 414C78A6 414C6EE9
414C6511 414C5B16 414C50F9 414C46BD 414C3C5D 414C31D9 414C2730 414C1C66 414C1176 414C065E
414BFB20 414BEFB8 414BE427 414BD86E 414BCC89 414BC079 414BB43F 414BA7D4 414B9B3D 414B8E9B
411071E6 41108037 41108E81 41109CD5 4110AB1A 4110B95D 4110C79F 4110D5DC 4110E436 4110F28A
411100E5 41110F40 41111D90 41112BE1 41113A35 41114879 411156C0 41116505 41117348 41118183
41118FB9 41119DEF 4111AC1F 4111BA4C 4111C878 4111D69B 4111E4BE 4111F2DA 411200F3 41120F07
41121D16 41122B28 4158605E 41586056 4158604E 41586046 4158603D 41586034 4158602C 41586024
41586052 41586090 415860D2 41586114 41586156 41586197 415861DC 41586219 41586259 41586299
415862DA 41586319 41586358 41586396 415863D4 41586410 4158644D 41586487 415864C4 415864FE
41586539 41586573 415865AC 415865F8 40EB61C5 40EB606E 40EB5EF2 40EB5DB4 40EB5C35 40EB5AE9
40EB5964 40EB57ED 40EB58F5 40EB5A96 40EB5C7C 40EB5E77 40EB6061 40EB6254 40EB6450 40EB663D
40EB682D 40EB6A29 40EB6C21 40EB6E18 40EB7004 40EB71FC 40EB73F6 40EB75E3 40EB77DE 40EB79CB
40EB7BC1 40EB7DB2 40EB7FB1 40EB819D 40EB8390 40EB8657 41188F05 41189E05 4118AD08 4118BC1D
4118CB2C 4118DA42 4118E960 4118F883 411907D5 4119172D 41192696 41193608 41194577 411954F1
41196478 411973F7 41198381 41199315 4119A2B0 4119B24B 4119C1EB 4119D195 4119E143 4119F0F7
411A00B5 411A1072 411A203B 411A3006 411A3FD8 411A4FAF 411A5F8B 411A6F77 4077A9B1 40781809
4078860C 4078F3D6 40796125 4079CDF5 407A3A99 407AA6CB 407B1022 407B7824 407BDFB6 407C46EB
407CAD8B 407D13EA 407D79ED 407DDF63 407E448D 407EA957 407F0DC3 407F71A3 407FD529 40803853
40809B09 4080FD6A 40815F67 4081C0E6 4082220D 408282C1 4082E2FA 408342DC 4083A247 4084004E

665

RECORD 2 OF FILE 32
LENGTH = 15168 BYTES


```
00000299 04DC0231 00030009 00000000 00000000 00000000 00030002 01760000 003C003C 00390000
0000AAAA AAAAAAAA 00000012 FB68931B 00090000 B1B1B1B3 09036E57 2F2F541C 642C0000 700010D5
98016991 8CE71C00 0C500000 0000CB00 000C8800 0000D000 000000CB 0C0000E8 000000D0 00000000
CB0C020C 88000000 96000000 85000000 9D710049 96710048 A471009C 93700038 80931400 C105008D
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 071D7D80 071D7D81 071D7D82 071D7D83
071D7D84 071D7D85 071D7D86 071D7D87 071D7D88 071D7D89 071D7D8A 071D7D8B 071D7D8C 071D7D8D
071D7D8E 071D7D8F 071D7D90 071D7D91 071D7D92 071D7D93 071D7D94 071D7D95 071D7D96 071D7D97
071D7D98 071D7D99 071D7D9A 071D7D9B 071D7D9C 071D7D9D 071D7D9E 071D7D9F 071D7DA0 071D7DA1
071D7DA2 071D7DA3 071D7DA4 071D7DA5 071D7DA6 071D7DA7 071D7DA8 071D7DA9 071D7DAA 071D7DAB
071D7DAC 071D7DAD 071D7DAE 071D7DAF 071D7DB0 071D7DB1 071D7DB2 071D7DB3 071D7DB4 071D7DB5
071D7DB6 071D7DB7 071D7DB8 071D7DB9 071D7DBA 071D7DBB 071D7DBC 071D7DBD 071D7DBE 071D7DBF
071D7DC0 071D7DC1 071D7DC2 071D7DC3 071D7DC4 071D7DC5 071D7DC6 071D7DC7 071D7DC8 071D7DC9
071D7DCA 071D7DCB 071D7DCC 071D7DCD 071D7DCE 071D7DCF 071D7DD0 071D7DD1 071D7DD2 071D7DD3
071D7DD4 071D7DD5 071D7DD6 071D7DD7 071D7DD8 071D7DD9 071D7DDA 071D7DDB 071D7DDC 071D7DDD
071D7DDE 071D7DDF 071D7DE0 071D7DE1 071D7DE2 071D7DE3 071D7DE4 071D7DE5 071D7DE6 071D7DE7
071D7DE8 071D7DE9 071D7DEA 071D7DEB 071D7DEC 071D7DED 071D7DEE 071D7DEF 071D7DF0 071D7DF1
071D7DF2 071D7DF3 071D7DF4 071D7DF5 071D7DF6 071D7DF7 071D7DF8 071D7DF9 071D7DFA 071D7DFB
071D7DFC 071D7DFD 071D7DFE 071D7DFF 413B2F56 413B2F94 413B2FD5 413B3015 413B3057 413B3096
413B30D6 413B3117 413B3156 413B3195 413B31D5 413B3216 413B3252 413B3291 413B32CE 413B330A
413B3348 413B3384 413B33C0 413B33FC 413B3437 413B3473 413B34AD 413B34E8 413B3522 413B355C
413B3595 413B35CE 413B3607 413B363F 413B3677 413B36AF C03AEC6A C03AEA54 C03AE7FD C03AE5AF
C03AE360 C03AE114 C03ADEC9 C03ADC93 C03ADA98 C03AD896 C03AD681 C03AD493 C03AD2CA C03AD10C
C03ACF6A C03ACDD2 C03ACC40 C03ACAD4 C03AC977 C03AC83B C03AC6F3 C03AC5D5 C03AC4D0 C03AC3D9
C03AC2DA C03AC20C C03AC13F C03AC09D C03AC005 C03ABF98 C03ABF0D C03ABEE5 414ECA08 414EBF86
414EB4F6 414EAA4B 414E9F7F 414E9499 414E8996 414E7E73 414E7330 414E67CE 414E5C4C 414E50A7
414E44E4 414E38FD 414E2CF3 414E20C6 414E1472 414E07FE 414DFB62 414DEEA1 414DE1BA 414DD4A9
414DC773 414DBA12 414DAC8A 414D9ED8 414D90FE 414D82F5 414D74BD 414D665D 414D57D0 414D490D
40F72F78 40F81228 40F8F45F 40F9D627 40FAB83A 40FB99A2 40FC7AEF 40FD5BF4 40FE3C38 40FF1C6D
40FFFC91 41100DC7 41101BB4 411029A2 41103788 41104569 4110534A 4110611D 41106EED 41107CB6
41108A7A 41109839 4110A5ED 4110B39F 4110C14B 4110CEED 4110DC87 4110EA1A 4110F7AB 4111052D
411112AD 41112023 415C5A07 415C5A68 415C5AD0 415C5B36 415C5B9F 415C5C04 415C5C6A 415C5CD1
415C5D32 415C5D95 415C5DF8 415C5E5C 415C5EB8 415C5F18 415C5F74 415C5FCF 415C602B 415C6084
415C60DC 415C6133 415C6189 415C61DE 415C6231 415C6284 415C62D6 415C6327 415C6375 415C63C2
415C640F 415C645A 415C64A5 415C64EC 40C9B320 40C9B36B 40C9B3DB 40C9B44E 40C9B4B0 40C9B523
40C9B58B 40C9B5DF 40C9B60B 40C9B63B 40C9B679 40C9B68A 40C9B699 40C9B68D 40C9B672 40C9B652
40C9B626 40C9B5E2 40C9B591 40C9B521 40C9B4C4 40C9B439 40C9B3A5 40C9B2FC 40C9B25F 40C9B199
40C9B0DB 40C9AFF5 40C9AF03 40C9ADEF 40C9ACF7 40C9ABA9 4117C048 4117CD2F 4117DA1B 4117E709
4117F405 41180101 41180E05 41181B0F 41182816 41183526 41184240 41184F60 41185C79 4118699D
411876C5 411883F2 4118912A 41189E5F 4118AB9C 4118B8DD 4118C625 4118D374 4118E0C3 4118EE1C
4118FB7B 411908DC 41191640 411923AC 41193121 41193E93 41194C11 41195991 40639F1D 40643A24
4064D472 40656E75 40660880 4066A221 40673B93 4067D4CF 40686DBE 40690686 40699F1F 406A3792
406ACF7C 406B675B 406BFEFC 406C9664 406D2DBE 406DC49C 406E5B5E 406EF1E1 406F8824 40701E45
4070B408 407149AD 4071DF06 4072741C 407308D7 40739D77 407431F6 4074C5F7 407559CA 4075ED8D
```

HEAO-1

A-2 SEP DATABASE

77-075A-02K

This data set consists of 31 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on an IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101215	C-032142	67	08/14/77 - 09/03/77
D-101216	C-032143	58	09/07/77 - 09/24/77
D-101217	C-032144	44	09/25/77 - 10/12/77
D-101218	C-032145	45	10/13/77 - 10/30/77
D-101219	C-032146	32	10/31/77 - 11/11/77
D-101220	C-032147	16	11/12/77 - 11/17/77
D-101221	C-032148	105	11/18/77 - 12/07/78
D-101222	C-032149	39	12/08/78 - 12/23/78
D-101223	C-032150	130	12/24/78 - 02/17/78
D-101224	C-032151	70	02/18/78 - 03/17/78
D-101225	C-032152	30	03/18/78 - 03/29/78
D-101226	C-032153	30	03/30/78 - 04/10/78
D-101227	C-032154	57	04/11/78 - 05/04/78
D-101228	C-032155	57	05/05/78 - 05/29/78
D-101229	C-032156	61	05/30/78 - 06/27/78
D-101230	C-032157	64	06/28/78 - 07/28/78
D-101231	C-032158	77	07/29/78 - 09/01/78
D-101232	C-032159	59	09/02/78 - 09/25/78
D-101233	C-032160	54	09/26/78 - 10/15/78
D-101234	C-032161	54	10/16/78 - 11/04/78
D-101235	C-032162	10	11/05/78 - 11/08/78
D-101236	C-032163	9	11/09/78 - 11/12/78
D-101237	C-032164	11	11/13/78 - 11/16/78
D-101238	C-032165	10	11/17/78 - 11/20/78
D-101239	C-032166	13	11/21/78 - 11/24/78
D-101240	C-032167	9	11/25/78 - 11/28/78
D-101241	C-032168	11	11/29/78 - 12/02/78
D-101242	C-032169	9	12/03/78 - 12/06/78
D-101243	C-032170	8	12/07/78 - 12/10/78
D-101244	C-032171	9	12/11/78 - 12/14/78
D-101245	C-032172	53	12/15/78 - 01/07/79

D101234

654 — 673

654 -365 289 → Days 673 -365 308 10/16/78 – 11/4/78

RECORD 2 OF FILE 1
LENGTH = 15168 BYTES

654

0000028E	00785618	00030009	00000000	00000000	00000000	00030002	00F50000	003C003C	003F0000
0000AAAA	AAAAAAAA	00000001	D6105061	000D0000	B1B1B1B3	0D032915	1513236B	16160000	700010D5
B0016905	5F56C400	0C500000	0000CB00	000C8800	0000D000	000000CB	0C0000E8	000000D0	00000000
CB0C020C	88000000	91000000	96000000	AA960049	A1930048	AC95009C	9A8E0038	07010000	8F1A006F
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	06ECA900	06ECA901	06ECA902	06ECA903
06ECA904	06ECA905	06ECA906	06ECA907	06ECA908	06ECA909	06ECA90A	06ECA90B	06ECA90C	06ECA90D
06ECA90E	06ECA90F	06ECA910	06ECA911	06ECA912	06ECA913	06ECA914	06ECA915	06ECA916	06ECA917
06ECA918	06ECA919	06ECA91A	06ECA91B	06ECA91C	06ECA91D	06ECA91E	06ECA91F	06ECA920	06ECA921
06ECA922	06ECA923	06ECA924	06ECA925	06ECA926	06ECA927	06ECA928	06ECA929	06ECA92A	06ECA92B
06ECA92C	06ECA92D	06ECA92E	06ECA92F	06ECA930	06ECA931	06ECA932	06ECA933	06ECA934	06ECA935
06ECA936	06ECA937	06ECA938	06ECA939	06ECA93A	06ECA93B	06ECA93C	06ECA93D	06ECA93E	06ECA93F
06ECA940	06ECA941	06ECA942	06ECA943	06ECA944	06ECA945	06ECA946	06ECA947	06ECA948	06ECA949
06ECA94A	06ECA94B	06ECA94C	06ECA94D	06ECA94E	06ECA94F	06ECA950	06ECA951	06ECA952	06ECA953
06ECA954	06ECA955	06ECA956	06ECA957	06ECA958	06ECA959	06ECA95A	06ECA95B	06ECA95C	06ECA95D
06ECA95E	06ECA95F	06ECA960	06ECA961	06ECA962	06ECA963	06ECA964	06ECA965	06ECA966	06ECA967
06ECA968	06ECA969	06ECA96A	06ECA96B	06ECA96C	06ECA96D	06ECA96E	06ECA96F	06ECA970	06ECA971
06ECA972	06ECA973	06ECA974	06ECA975	06ECA976	06ECA977	06ECA978	06ECA979	06ECA97A	06ECA97B
06ECA97C	06ECA97D	06ECA97E	06ECA97F	4137FDD3	4137FDBF	4137FDAA	4137FD96	4137FD82	4137FD6E
4137FD59	4137FD45	4137FD30	4137FD1C	4137FD07	4137FCF3	4137FCDF	4137FCCA	4137FCB5	4137FCA0
4137FC8C	4137FC76	4137FC62	4137FC4D	4137FC37	4137FC23	4137FC0E	4137FBF9	4137FBE4	4137FBCE
4137FBB9	4137FBA3	4137FB8E	4137FB79	4137FB64	4137FB4E	C0249C05	C0249EA6	C024A146	C024A3D4
C024A652	C024A8CD	C024AB35	C024AD9A	C024AFF1	C024B234	C024B477	C024B69C	C024B8C7	C024BAD9
C024BCEF	C024BEF3	C024C0E2	C024C2D9	C024C4AA	C024C685	C024C84A	C024CA03	C024CBB0	C024CD50
C024CEFA	C024D086	C024D205	C024D378	C024D4E8	C024D64B	C024D79E	C024D88F	411BECB4	411BE670
411BE01A	411BD9B9	411BD346	411BCCC0	411BC62C	411BBF86	411BB8CF	411BB208	411BAB2B	411BA441
411B9D3F	411B9631	411B8F09	411B87D2	411B8084	411B7921	411B71AE	411B6A22	411B6284	411B5ACD
411B52FF	411B4B1E	411B4323	411B3B0F	411B32E3	411B2AA0	411B2245	411B19D0	411B113E	411B0896
C0E705B9	C0E7FEFA	C0E8F87F	C0E9F143	C0EAEA85	C0EBE42C	C0ECDD8B	C0EDD6D5	C0EED02C	C0EFC97D
C0F0C33A	C0F1BC8A	C0F2B674	C0F3AF7C	C0F4A94F	C0F5A29A	C0F69C6E	C0F79610	C0F88F87	C0F98918
C0FA8279	C0FB7C41	C0FC75F3	C0FD6F65	C0FE68CE	C0FF6293	C11005C4	C110155D	C11024F3	C1103487
C1104424	C11053C6	4158790E	415878DE	415878AE	4158787E	4158784F	41587820	415877F1	415877C2
41587792	41587765	41587736	41587709	415876DB	415876AD	41587680	41587653	41587626	415875F7
415875CC	4158759F	41587572	41587547	4158751B	415874F0	415874C4	41587498	4158746D	41587441
41587417	415873EC	415873C2	41587399	40EF20D2	40EF1E84	40EF1C39	40EF1A00	40EF17D4	40EF15AE
40EF1398	40EF1187	40EF0F84	40EF0D92	40EF0BA4	40EF09D0	40EF07F7	40EF0638	40EF0474	40EF02C2
40EF0125	40EEFF83	40EEFE01	40EEFC78	40EEFB06	40EEF99C	40EEF841	40EEF6EF	40EEF598	40EEF45F
40EEF330	40EEF20E	40EEF0EE	40EEEFDC	40EEEED8	40EEEE36	4148DC1F	4148EB29	4148FA3F	41490951
41491873	414927A2	414936D6	4149460F	41495551	4149649B	414973F4	4149834E	414992BA	4149A221
4149B19C	4149C117	4149D0A3	4149E034	4149EFCC	4149FF6D	414A0F14	414A1ECB	414A2E89	414A3E4C
414A4E17	414A5DF1	414A6DD3	414A7DBD	414A8DAC	414A9DA3	414AADAC	414ABDC5	C064906C	C0651133
C06591DD	C066611CF	C06691AB	C0671173	C06790BE	C0680FB6	C0688E64	C0690CAD	C0698AEA	C06A0887
C06A862C	C06B0306	C06B7FF8	C06BFC4A	C06C7882	C06CF464	C06D6FB2	C06DEACE	C06E6573	C06EDFEA
C06F59FE	C06FD391	C0704CDF	C070C5EF	C0713E92	C071B6CE	C0722E93	C072A5EF	C0731D2A	C07393DD

(7)

RECORD 2 OF FILE 54
LENGTH = 15168 BYTES

000002A1	0518A242	0001000B	00000000	00000000	000F0000	00030002	028A0000	003C003C	00000000
0000AAAA	AAAAAAAA	00000013	E839D5A9	001DFFFF	B1B1B1B1	1D005454	54541C1C	1C1C0000	700010D5
98016B80	DA567500	00500000	0000CB00	000C8800	0000D000	000000CB	0C0000E8	000000D0	00000000
CB0C000C	88000000	A3000000	8C000000	A8970049	A1940048	AC96009C	9A8E0038	09010000	8E15008D
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	073EA380	073EA381	073EA382	073EA383
073EA384	073EA385	073EA386	073EA387	073EA388	073EA389	073EA38A	073EA38B	073EA38C	073EA38D
073EA38E	073EA38F	073EA390	073EA391	073EA392	073EA393	073EA394	073EA395	073EA396	073EA397
073EA398	073EA399	073EA39A	073EA39B	073EA39C	073EA39D	073EA39E	073EA39F	073EA3A0	073EA3A1
073EA3A2	073EA3A3	073EA3A4	073EA3A5	073EA3A6	073EA3A7	073EA3A8	073EA3A9	073EA3AA	073EA3AB
073EA3AC	073EA3AD	073EA3AE	073EA3AF	073EA3B0	073EA3B1	073EA3B2	073EA3B3	073EA3B4	073EA3B5
073EA3B6	073EA3B7	073EA3B8	073EA3B9	073EA3BA	073EA3BB	073EA3BC	073EA3BD	073EA3BE	073EA3BF
073EA3C0	073EA3C1	073EA3C2	073EA3C3	073EA3C4	073EA3C5	073EA3C6	073EA3C7	073EA3C8	073EA3C9
073EA3CA	073EA3CB	073EA3CC	073EA3CD	073EA3CE	073EA3CF	073EA3D0	073EA3D1	073EA3D2	073EA3D3
073EA3D4	073EA3D5	073EA3D6	073EA3D7	073EA3D8	073EA3D9	073EA3DA	073EA3DB	073EA3DC	073EA3DD
073EA3DE	073EA3DF	073EA3E0	073EA3E1	073EA3E2	073EA3E3	073EA3E4	073EA3E5	073EA3E6	073EA3E7
073EA3E8	073EA3E9	073EA3EA	073EA3EB	073EA3EC	073EA3ED	073EA3EE	073EA3EF	073EA3F0	073EA3F1
073EA3F2	073EA3F3	073EA3F4	073EA3F5	073EA3F6	073EA3F7	073EA3F8	073EA3F9	073EA3FA	073EA3FB
073EA3FC	073EA3FD	073EA3FE	073EA3FF	413D2E25	413D2E30	413D2E3A	413D2E44	413D2E4D	413D2E56
413D2E5E	413D2E66	413D2E84	413D2EB6	413D2EE4	413D2F14	413D2F44	413D2F74	413D2FA1	413D2FCF
413D2FFD	413D3028	413D3052	413D307C	413D30A4	413D30CC	413D30F3	413D3117	413D313B	413D315E
413D3182	413D31A3	413D31C2	413D31E2	413D3201	413D3220	C045439F	C0454880	C0454D7A	C0455277
C0455797	C0455CBA	C04561FE	C0456738	C0456A62	C0456C01	C0456DA3	C0456F23	C04570A6	C045722E
C04573C8	C0457552	C04576FD	C04578BE	C0457A86	C0457C66	C0457E4F	C045804D	C0458264	C0458491
C04586D3	C045891C	C0458B7E	C0458DF9	C045909A	C0459335	C04595EE	C045986E	411E844F	411E7924
411E6DDA	411E6271	411E56E7	411E4B40	411E3F81	411E339F	411E27D5	411E1C17	411E1033	411E0439
411DF822	411DEBE9	411DDF87	411DD30C	411DC66B	411DB9A2	411DACB3	411D9FA4	411D926B	411D8510
411D7785	411D69D5	411D5BFD	411D4DFE	411D3FD8	411D317E	411D22F6	411D1449	411D056E	411CF657
C0E2830A	C0E36CAA	C0E45647	C0E53FF3	C0E62985	C0E712EA	C0E7FB7C	C0E8E455	C0E9CE74	C0EAB983
C0EBA4B3	C0EC8F67	C0ED79D5	C0EE6425	C0EF4E98	C0F0387F	C0F12232	C0F20BC4	C0F2F553	C0F3DE33
C0F4C70D	C0F5AF73	C0F6980E	C0F78007	C0F867B7	C0F94F04	C0FA35E1	C0FB1CDC	C0FC0386	C0FCE9A9
C0FDCF62	C0FEB64C	415E3EE9	415E3EC0	415E3E95	415E3E6A	415E3E3C	415E3E0E	415E3DDD	415E3DAC
415E3DAA	415E3DCE	415E3DED	415E3E10	415E3E34	415E3E56	415E3E75	415E3E96	415E3EB4	415E3ECF
415E3EE9	415E3F01	415E3F17	415E3F2C	415E3F3F	415E3F4F	415E3F5C	415E3F69	415E3F75	415E3F7D
415E3F82	415E3F88	415E3F8B	415E3F91	40B1EB4C	40B1E6C9	40B1E237	40B1DDA4	40B1D8FB	40B1D451
40B1CF92	40B1CAE1	40B1C739	40B1C44A	40B1C173	40B1BEA9	40B1BBD9	40B1B90C	40B1B645	40B1B37D
40B1B0A1	40B1ADCC	40B1AAF0	40B1A809	40B1A524	40B1A231	40B19F31	40B19C2D	40B19924	40B19613
40B192EB	40B18FC7	40B18C8C	40B18952	40B18609	40B182EE	41492865	4149338E	41493EBD	414949F6
41495534	41496078	41496BBA	41497708	41498280	41498E19	414999BD	4149A565	4149B112	4149BCC7
4149C886	4149D448	4149E011	4149EBE1	4149F7BB	414A0395	414A0F79	414A1B62	414A2757	414A334E
414A3F4C	414A4B4F	414A5759	414A636E	414A6F8A	414A7BAC	414A87D3	414A9419	C04A9783	C04B5AC0
C04C1E30	C04CE1C8	C04DA587	C04E6940	C04F2C88	C04FF022	C050B251	C0517363	C05234C4	C052F5AA
C053B669	C0547735	C055385D	C055F90D	C056B9D3	C0577AC7	C0583BD9	C058FC94	C059BD7E	C05A7E3B
C05B3F62	C05C0049	C05CC133	C05D81F2	C05E428D	C05F0396	C05FC4B0	C0608575	C0614630	C06207DA

D/01445
8/14/77 - 4/10/78 226 - 465

RECORD 1 OF FILE 1
LENGTH = 25968 BYTES

276

000000E2	006E08A9	000000E2	030028A9	00000000	00000000	00000000	0000011A	412802F5	4040F2AE
00000000	00000000	00000000	00000000	00000000	3F477D1A	3F477D1A	3F477D1A	3F477D1A	3F8EFA35
3F8EFA35	3F8EFA35	3F8EFA35	3FD67750	3FD67750	3FD67750	3FD67750	4011DF46	4011DF46	4011DF46
4011DF46	40165718	40165718	40165718	40165718	401ACEEA	401ACEEA	401ACEEA	401ACEEA	401F46BB
401F46BB	401F46BB	401F46BB	4023BE8D	4023BE8D	4023BE8D	4023BE8D	4028365F	4028365F	4028365F
4028365F	402CAE30	402CAE30	402CAE30	402CAE30	40312602	40312602	40312602	40312602	40359DD4
40359DD4	40359DD4	40359DD4	403A15A5	403A15A5	403A15A5	403A15A5	403E8D77	403E8D77	403E8D77
403E8D77	40430549	40430549	40430549	40430549	40477D1A	40477D1A	40477D1A	40477D1A	404BF4EC
404BF4EC	404BF4EC	404BF4EC	40506CBE	40506CBE	40506CBE	40506CBE	4054E48F	4054E48F	4054E48F
4054E48F	40595C61	40595C61	40595C61	40595C61	405DD433	405DD433	405DD433	405DD433	40624C04
40624C04	40624C04	40624C04	4066C3D6	4066C3D6	4066C3D6	4066C3D6	406B3BA8	406B3BA8	406B3BA8
406B3BA8	406FB379	406FB379	406FB379	406FB379	40742B4B	40742B4B	40742B4B	40742B4B	4078A31D
4078A31D	4078A31D	4078A31D	407D1AEE	407D1AEE	407D1AEE	407D1AEE	408192C0	408192C0	408192C0
408192C0	40860A92	40860A92	40860A92	40860A92	408A8263	408A8263	408A8263	408A8263	408EFA35
408EFA35	408EFA35	408EFA35	40937207	40937207	40937207	40937207	4097E9D8	4097E9D8	4097E9D8
4097E9D8	409C61AA	409C61AA	409C61AA	409C61AA	40A0D97C	40A0D97C	40A0D97C	40A0D97C	40A5514D
40A5514D	40A5514D	40A5514D	40A9C91F	40A9C91F	40A9C91F	40A9C91F	40AE40F1	40AE40F1	40AE40F1
40AE40F1	40B2B8C2	40B2B8C2	40B2B8C2	40B2B8C2	40B73094	40B73094	40B73094	40B73094	40BBA866
40BBA866	40BBA866	40BBA866	40C02038	40C02038	40C02038	40C02038	40C49809	40C49809	40C49809
40C49809	40C90FDB	40C90FDB	40C90FDB	40C90FDB	40CD87AD	40CD87AD	40CD87AD	40CD87AD	40D1FF7E
40D1FF7E	40D1FF7E	40D1FF7E	40D67750	40D67750	40D67750	40D67750	40DAEF22	40DAEF22	40DAEF22
40DAEF22	40DF66F3	40DF66F3	40DF66F3	40DF66F3	40E3DEC5	40E3DEC5	40E3DEC5	40E3DEC5	40E85697
40E85697	40E85697	40E85697	40ECCE68	40ECCE68	40ECCE68	40ECCE68	40F1463A	40F1463A	40F1463A
40F1463A	40F5BE0C	40F5BE0C	40F5BE0C	40F5BE0C	40FA35DD	40FA35DD	40FA35DD	40FA35DD	40FEADAF
40FEADAF	40FEADAF	40FEADAF	41103258	41103258	41103258	41103258	411079D5	411079D5	411079D5
411079D5	4110C152	4110C152	4110C152	4110C152	411108CF	411108CF	411108CF	411108CF	4111504C
4111504C	4111504C	4111504C	411197C9	411197C9	411197C9	411197C9	4111DF46	4111DF46	4111DF46
4111DF46	411226C3	411226C3	411226C3	411226C3	41126E40	41126E40	41126E40	41126E40	4112B5BE
4112B5BE	4112B5BE	4112B5BE	4112FD3B	4112FD3B	4112FD3B	4112FD3B	411344B8	411344B8	411344B8
411344B8	41138C35	41138C35	41138C35	41138C35	4113D3B2	4113D3B2	4113D3B2	4113D3B2	41141B2F
41141B2F	41141B2F	41141B2F	411462AC	411462AC	411462AC	411462AC	4114AA29	4114AA29	4114AA29
4114AA29	4114F1A6	4114F1A6	4114F1A6	4114F1A6	41153923	41153923	41153923	41153923	411580A1
411580A1	411580A1	411580A1	4115C81E	4115C81E	4115C81E	4115C81E	41160F9B	41160F9B	41160F9B
41160F9B	41165718	41165718	41165718	41165718	41169E95	41169E95	41169E95	41169E95	4116E612
4116E612	4116E612	4116E612	41172D8F	41172D8F	41172D8F	41172D8F	4117750C	4117750C	4117750C
4117750C	4117BC89	4117BC89	4117BC89	4117BC89	41180407	41180407	41180407	41180407	41184B84
41184B84	41184B84	41184B84	41189301	41189301	41189301	41189301	4118DA7E	4118DA7E	4118DA7E
4118DA7E	411921FB	411921FB	411921FB	411921FB	41196978	41196978	41196978	41196978	4119B0F5
4119B0F5	4119B0F5	4119B0F5	4119F872	4119F872	4119F872	4119F872	411A3FEF	411A3FEF	411A3FEF
411A3FEF	411A876C	411A876C	411A876C	411A876C	411ACEEA	411ACEEA	411ACEEA	411ACEEA	411B1667
411B1667	411B1667	411B1667	411B5DE4	411B5DE4	411B5DE4	411B5DE4	411BA561	411BA561	411BA561
411BA561	411BECDE	411BECDE	411BECDE	411BECDE	411C345B	411C345B	411C345B	411C345B	411C7BD8
411C7BD8	411C7BD8	411C7BD8	411CC355	411CC355	411CC355	411CC355	411D0AD2	411D0AD2	411D0AD2
411D0AD2	411D524F	411D524F	411D524F	411D524F	411D99CD	411D99CD	411D99CD	411D99CD	411DE14A
411DE14A	411DE14A	411DE14A	411E28C7	411E28C7	411E28C7	411E28C7	411E7044	411E7044	411E7044
411E7044	411EB7C1	411EB7C1	411EB7C1	411EB7C1	411EFF3E	411EFF3E	411EFF3E	411EFF3E	411F46BB
411F46BB	411F46BB	411F46BB	411F8E38	411F8E38	411F8E38	411F8E38	411FD5B5	411FD5B5	411FD5B5
411FD5B5	41201D33	41201D33	41201D33	41201D33	412064B0	412064B0	412064B0	412064B0	4120AC2D
4120AC2D	4120AC2D	4120AC2D	4120F3AA	4120F3AA	4120F3AA	4120F3AA	41213B27	41213B27	41213B27
41213B27	412182A4	412182A4	412182A4	412182A4	4121CA21	4121CA21	4121CA21	4121CA21	4122119E
4122119E	4122119E	4122119E	4122591B	4122591B	4122591B	4122591B	4122A098	4122A098	4122A098
4122A098	4122E816	4122E816	4122E816	4122E816	41232F93	41232F93	41232F93	41232F93	41237710

465

RECORD 1 OF FILE 480
LENGTH = 25968 BYTES


```
000001D1 0301A0C9 000001D2 006D64CA 00000000 00000000 00000000 00000028 40531007 40232B06
00000000 00000000 00000000 00000000 00000000 3F477D1A 3F477D1A 3F477D1A 3F477D1A 3F8EFA35
3F8EFA35 3F8EFA35 3F8EFA35 3FD67750 3FD67750 3FD67750 3FD67750 4011DF46 4011DF46 4011DF46
4011DF46 40165718 40165718 40165718 40165718 401ACEEA 401ACEEA 401ACEEA 401ACEEA 401F46BB
401F46BB 401F46BB 401F46BB 4023BE8D 4023BE8D 4023BE8D 4023BE8D 4028365F 4028365F 4028365F
4028365F 402CAE30 402CAE30 402CAE30 402CAE30 40312602 40312602 40312602 40312602 40359DD4
40359DD4 40359DD4 40359DD4 403A15A5 403A15A5 403A15A5 403A15A5 403E8D77 403E8D77 403E8D77
403E8D77 40430549 40430549 40430549 40430549 40477D1A 40477D1A 40477D1A 40477D1A 404BF4EC
404BF4EC 404BF4EC 404BF4EC 40506CBE 40506CBE 40506CBE 40506CBE 4054E48F 4054E48F 4054E48F
4054E48F 40595C61 40595C61 40595C61 40595C61 405DD433 405DD433 405DD433 405DD433 40624C04
40624C04 40624C04 40624C04 4066C3D6 4066C3D6 4066C3D6 4066C3D6 406B3BA8 406B3BA8 406B3BA8
406B3BA8 406FB379 406FB379 406FB379 406FB379 40742B4B 40742B4B 40742B4B 40742B4B 4078A31D
4078A31D 4078A31D 4078A31D 407D1AEE 407D1AEE 407D1AEE 407D1AEE 408192C0 408192C0 408192C0
408192C0 40860A92 40860A92 40860A92 40860A92 408A8263 408A8263 408A8263 408A8263 408EFA35
408EFA35 408EFA35 408EFA35 40937207 40937207 40937207 40937207 4097E9D8 4097E9D8 4097E9D8
4097E9D8 409C61AA 409C61AA 409C61AA 409C61AA 40A0D97C 40A0D97C 40A0D97C 40A0D97C 40A5514D
40A5514D 40A5514D 40A5514D 40A9C91F 40A9C91F 40A9C91F 40A9C91F 40AE40F1 40AE40F1 40AE40F1
40AE40F1 40B2B8C2 40B2B8C2 40B2B8C2 40B2B8C2 40B73094 40B73094 40B73094 40B73094 40BBA866
40BBA866 40BBA866 40BBA866 40C02038 40C02038 40C02038 40C02038 40C49809 40C49809 40C49809
40C49809 40C90FDB 40C90FDB 40C90FDB 40C90FDB 40CD87AD 40CD87AD 40CD87AD 40CD87AD 40D1FF7E
40D1FF7E 40D1FF7E 40D1FF7E 40D67750 40D67750 40D67750 40D67750 40DAEF22 40DAEF22 40DAEF22
40DAEF22 40DF66F3 40DF66F3 40DF66F3 40DF66F3 40E3DEC5 40E3DEC5 40E3DEC5 40E3DEC5 40E85697
40E85697 40E85697 40E85697 40ECCE68 40ECCE68 40ECCE68 40ECCE68 40F1463A 40F1463A 40F1463A
40F1463A 40F5BE0C 40F5BE0C 40F5BE0C 40F5BE0C 40FA35DD 40FA35DD 40FA35DD 40FA35DD 40FEADAF
40FEADAF 40FEADAF 40FEADAF 41103258 41103258 41103258 41103258 411079D5 411079D5 411079D5
411079D5 4110C152 4110C152 4110C152 4110C152 411108CF 411108CF 411108CF 411108CF 4111504C
4111504C 4111504C 4111504C 411197C9 411197C9 411197C9 411197C9 4111DF46 4111DF46 4111DF46
4111DF46 411226C3 411226C3 411226C3 411226C3 41126E40 41126E40 41126E40 41126E40 4112B5BE
4112B5BE 4112B5BE 4112B5BE 4112FD3B 4112FD3B 4112FD3B 4112FD3B 411344B8 411344B8 411344B8
411344B8 41138C35 41138C35 41138C35 41138C35 4113D3B2 4113D3B2 4113D3B2 4113D3B2 41141B2F
41141B2F 41141B2F 41141B2F 411462AC 411462AC 411462AC 411462AC 4114AA29 4114AA29 4114AA29
4114AA29 4114F1A6 4114F1A6 4114F1A6 4114F1A6 41153923 41153923 41153923 41153923 411580A1
411580A1 411580A1 411580A1 4115C81E 4115C81E 4115C81E 4115C81E 41160F9B 41160F9B 41160F9B
41160F9B 41165718 41165718 41165718 41165718 41169E95 41169E95 41169E95 41169E95 4116E612
4116E612 4116E612 4116E612 41172D8F 41172D8F 41172D8F 41172D8F 4117750C 4117750C 4117750C
4117750C 4117BC89 4117BC89 4117BC89 4117BC89 41180407 41180407 41180407 41180407 41184B84
41184B84 41184B84 41184B84 41189301 41189301 41189301 41189301 4118DA7E 4118DA7E 4118DA7E
4118DA7E 411921FB 411921FB 411921FB 411921FB 41196978 41196978 41196978 41196978 4119B0F5
4119B0F5 4119B0F5 4119B0F5 4119F872 4119F872 4119F872 4119F872 411A3FEF 411A3FEF 411A3FEF
411A3FEF 411A876C 411A876C 411A876C 411A876C 411ACEEA 411ACEEA 411ACEEA 411ACEEA 411B1667
411B1667 411B1667 411B1667 411B5DE4 411B5DE4 411B5DE4 411B5DE4 411BA561 411BA561 411BA561
411BA561 411BECDE 411BECDE 411BECDE 411BECDE 411C345B 411C345B 411C345B 411C345B 411C7BD8
411C7BD8 411C7BD8 411C7BD8 411CC355 411CC355 411CC355 411CC355 411D0AD2 411D0AD2 411D0AD2
411D0AD2 411D524F 411D524F 411D524F 411D524F 411D99CD 411D99CD 411D99CD 411D99CD 411DE14A
411DE14A 411DE14A 411DE14A 411E28C7 411E28C7 411E28C7 411E28C7 411E7044 411E7044 411E7044
411E7044 411EB7C1 411EB7C1 411EB7C1 411EB7C1 411EFF3E 411EFF3E 411EFF3E 411EFF3E 411F46BB
411F46BB 411F46BB 411F46BB 411F8E38 411F8E38 411F8E38 411F8E38 411FD5B5 411FD5B5 411FD5B5
411FD5B5 41201D33 41201D33 41201D33 41201D33 412064B0 412064B0 412064B0 412064B0 4120AC2D
4120AC2D 4120AC2D 4120AC2D 4120F3AA 4120F3AA 4120F3AA 4120F3AA 41213B27 41213B27 41213B27
41213B27 412182A4 412182A4 412182A4 412182A4 4121CA21 4121CA21 4121CA21 4121CA21 4122119E
4122119E 4122119E 4122119E 4122591B 4122591B 4122591B 4122591B 4122A098 4122A098 4122A098
4122A098 4122E816 4122E816 4122E816 4122E816 41232F93 41232F93 41232F93 41232F93 41237710
```

HEAO-1

A-2 MAP DATABASE

77-075A-02M

This data set consists of 3 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on an IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101445	C-032173	480	08/14/77 - 04/10/78
D-101446	C-032174	464	04/11/78 - 11/28/78
D-101447	C-032175	84	11/29/78 - 01/09/79

77-075A-02M

CSC/TM-81/6217

HIGH ENERGY ASTRONOMY OBSERVATORY-A2 POINT PROGRAM DESCRIPTION AND OPERATOR'S GUIDE

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-24350
Task Assignment 717

DECEMBER 1981

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-80/6044

HIGH ENERGY ASTRONOMY OBSERVATORY SATELLITE A (HEAO-A2)
SLAP PROGRAM DESCRIPTION AND OPERATORS GUIDE

Prepared by

COMPUTER SCIENCES CORPORATION

For

GODDARD SPACE FLIGHT CENTER

Under

Contract NAS 5-24350
Task Assignment 604

Prepared by:

K. Tolbert 6/9/80
K. Tolbert Date

Approved by:

A. R. Stottlemyer 12 June 80
Dr. A. Stottlemyer Date
Section Manager

R. F. Williams June 13, 1980
R. Williams Date
Department Manager

ABSTRACT

The cosmic ray X-ray experiment (A2) onboard the first High Energy Astronomy Observatory Satellite (HEAO-1) is designed to survey the emission of nonsolar X-rays over the entire sky. The HEAO-A2 data processing system provides computerized analysis and bulk data processing for this experiment at Goddard Space Flight Center (GSFC). The Second Look Analysis Program (SLAP) provides a complete summary of the experiment status and produces the XRATES data base which is used for data analysis. This document is a complete description of both the form and operational procedures for this program as it exists on the SACC IBM S/360 computer system.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

SECTION 1 - INTRODUCTION

The first High Energy Astronomy Observatory (HEAO-1) satellite was launched in August 1977, with the mission of surveying the full sky for non-solar X-ray emission over a wide range of X-ray energies. The A2 experiment consists of six detectors which, between them, cover a range in X-ray energy from 0.25 KeV to 60 KeV, and is designed to provide systematics free energy spectrum data for point and extended sources of X-rays. The experiment is mounted so as to observe the sky in a direction perpendicular to the satellite spin axis. With this orientation, each detector scans a 3-degree wide great circle of the sky each 30 minutes, and, as the spin axis precesses to point at the Sun, observes the full sky over a period of 6 months.

The six detectors consist of two Low Energy Detectors (LEDs), one Medium Energy Detector (MED), and three High Energy Detectors (HEDs). Each detector observes two co-axial fields of view separately, one collimated to 3° by 3° full width at half maximum (FWHM) and the other either 3° by $1\ 1/2^{\circ}$ or 3° by 6°. Each field of view is observed by a multi-wire gas proportional chamber with separate outputs for each field of view in two layers of anodes, and also for exterior layers of anodes which are used to discriminate against charged particles. The data output from each detector consists of the following types: engineering analog parameters (analog status), digital experiment parameters (digital status), raw anode counting rates (Housekeeping scalers), standard coincidence counting rates (Discovery scalers), pulse height analyzed rates (PHA histograms), calibration pulse height analyzed events (Calibration data), and a type with a variety of counting rate versus time output modes (Delta-t computer).

Program SLAP has two basic functions. The first is the production of printout and optional plots for use in diagnosing problems with the experiment. The primary printout is a complete summary of the experiment status for archiving.

The plots are in the form of detector counting rates as a function of ecliptic scan angle. All basic scaler rates are displayed, as well as many calculated rates. In addition, the flags from the MAX input tape are displayed. The second of the two basic functions is the production of the specialized XRATES data base for use by the experimenters. This data base includes selected data from all formats with X-ray data, as well as a more comprehensive set of data quality flags.

SECTION 2 - OVERVIEW

2.1 SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules to perform separate tasks for quality control, establishing data bases for more convenient and efficient analysis, and performing some preliminary analysis of the data. The system is designed to perform both as a "Quicklook", almost real-time, processor and as an off-line "Production" data analysis system. The system design incorporates the ability to perform both of these functions in parallel, and also to process large quantities of data in parallel. Figure 2-1 illustrates the system flow. This entire system is in operation on the SACC IBM 360/75 and 360/91 computers at GSFC.

The data input to the system is received from GSFC's Information Processing Division on magnetic tape in a format defined by the NASA document X-565-77-60, "Data Processing Requirements for High-Energy Observatory A (HEAO-A)", H. Linder, June 1977. Quicklook and Production data both have the same data and file format, differing only in the accuracy of the satellite attitude and orbit parameters. Quicklook data is normally produced for one orbit per day, and is available within 8 hours of transmission, while Production data is produced for all telemetry, and is available within 6 weeks of transmission. In addition to the experiment data tapes, a Command Summary tape will be produced by Marshall Space Flight Center and delivered to the experimenters. This tape contains only a record of commands sent and acknowledged by the satellite. The X-ray Source Catalog was compiled by the A2 experimenters, and incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disc file on a PDP-11/70 computer in the Laboratory for High Energy Astrophysics at GSFC. A special version of this catalog, for use by the main system, is copied onto a temporary or "scratch" tape, and copied onto disc by the SACC computers.

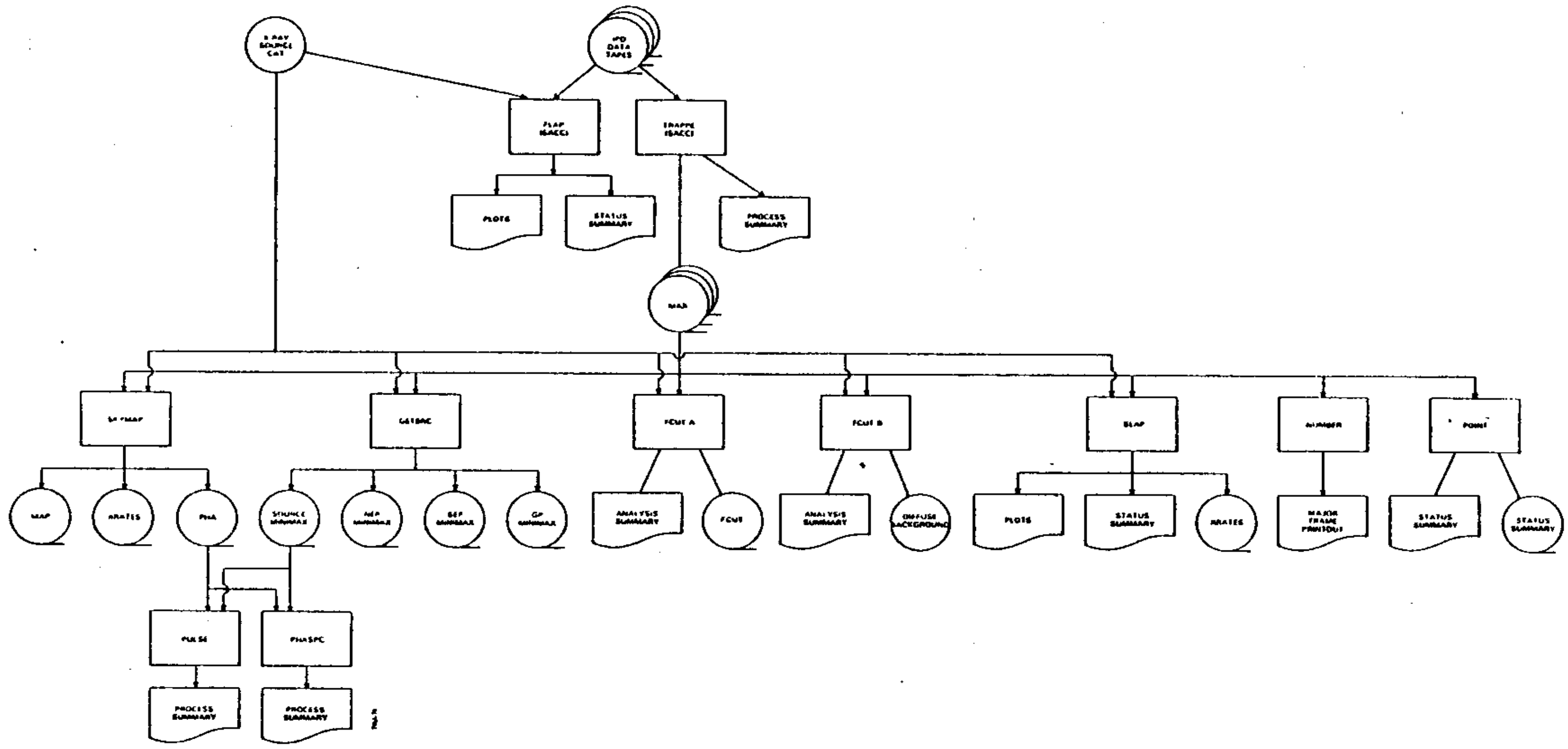


Figure 2-1. HEAO-A2 Data Processing System

The first processing of received data performs a series of detailed tests to evaluate data quality and experiment health and status, and also displays some of the raw data in a way which allows some very preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

The next stage of data processing is the production of a restructured data base (MAX), which serves to ease the data analysis. This is done by re-formatting the data into a FORTRAN-accessible format, re-ordering the data from telemetry stream order to accumulation time order, and by setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Re-blocking and Production Processing Executive (FRAPPE) is the program which reads an IPD format tape and produces the MAX data base. The file structure of the MAX data base is centered on the changes in the spin axis position which occur approximately every 12 hours, with a file mark occurring at each spin axis change, and additional marks only for large (greater than 10 major frames) gaps in the data.

A series of modules have been set up which use the MAX data base as input, and which perform preliminary analysis functions and also produce several condensed data bases.

The first of these modules is the Second Look Analysis Program (SLAP). This program generates a complete, detailed experiment status report, a complete set of detector counting rate plots, and a condensed data base (XRATES) of selected detector rates. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest. This program is used to process all Quicklook and Production data.

A second module is designed to produce a very detailed output from analysis of limited segments of data. This module, program NUMBER, examines the data on a Major Frame basis, and generates line printer output for a selected list of data including scaler counting rates, pulse height analysis, and temporal data. Full output from a Major Frame is approximately six pages long, and includes raw data and output from data analysis.

Three modules that create condensed data bases are SKYMAP, GETSRC, and FCUT. SKYMAP is run on all Production data and creates up to three specialized data bases. The first, MAP, contains Discovery Scaler data averaged over time and ordered by the observed location of the sky. The second and third, PHA and XRATES, contain PHA data and Discovery Scaler data respectively, for Major Frames with good data. GETSRC extracts Major Frame records from the MAX tape whenever a selected location of the sky is being observed, and places these records in time order on a separate output tape (MINI-MAX data base). GETSRC is used routinely to create tapes for the data for the North Ecliptic Pole, South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations are created upon request.

There are two segments of the FCUT data analysis program which performs routine analysis of Production data. FCUT B calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, and performs a parameterization of the non-X-ray background. FCUT A searches for new point sources and performs a detailed analysis of the rates of known X-ray sources, forming a data base containing these last results.

Program POINT produces a summary of detector digital status during all HEAO points at sources. Input to the program is the MAX data base and the TRW Pointing list, a compilation of point times and coordinates based on TRW data. For each run a printout is generated giving both TRW information and actual point coordinates and times; a separate printout is produced for digital status changes during points. An output tape is written to allow later copies of the digital status reports.

The XRATES, MAP, PHA, and FCUT data bases are designed to allow their use with mini-computers, while the MINI-MAX data will normally be limited to large computers due to physical record size. Detailed analysis programs generally use these specialized data bases as input.

Two of these analysis programs are PHASPC and PULSE. PHASPC accumulates PHA and Discovery Scaler data for sources and background regions; PULSE is similar to PHASPC but has the added capability of dividing a pulse cycle into a number of segments and accumulating data for each segment separately. These programs use either the PHA or GETSRC data base as input and are run by the scientists for selected time intervals and sources.

2.2 PROGRAM OVERVIEW

There are two versions of program SLAP, one of which is a subset of the other. The full SLAP Program (SLAP I) performs three primary functions: the plotting of Discovery scaler rates information in such a format as to allow preliminary X-ray source investigation, the formation of a condensed data base (XRATES) of selected detector rates, and the development of a detailed experiment status report. After production processing of HEAO data began, it became apparent that it was not necessary to produce plots on a routine basis, but only occasionally for particular intervals of data. However, rather than simply running SLAP I with the plotting option set to false, since it requires a large region of core (550 K) largely due to the plotting arrays, a new version of SLAP was created (SLAP II) to produce only the XRATES data base and the experiment status report. This document describes SLAP I, but SLAP II is identical to SLAP I with all references to plotting removed.

Primary input to SLAP is the MAX data base. All experiment data formats are accepted by SLAP, however, for RAM0 only the experiment status report is produced.

2.2.1 Plots

SLAP produces plots on the line printer and/or plot tape (CalComp or microfilm) at the option of the user. For plotting, data from minor frames with bit errors or padded data is handled as follows: The absolute value of data with bit errors (flagged by negative values on the MAX data base) is used, but the data is limited to a maximum value before plotting; an 'N' is plotted at scan angles at which fill data occurs. If no data falls in a particular bin (each bin corresponds to one degree in ecliptic scan angle), an 'A' is plotted at the corresponding angle. If two values fall in the same bin, they are averaged. Each set of plots covers a complete rotation of the detector axis and is phased at 0 degrees. A set of plots includes the following:

For each of six detectors:

a. Raw discovery scaler rate for each (of 8) scaler using the 5.12 second sum as the rate.

b. For detector layers 1 and 2 separately -

(1) 2 * DS(SFOV) - DS(LFOV)

(2) DS(LFOV) - DS(SFOV)

where DS(SFOV) and DS(LFOV) are the 5.12 second rates for the discovery scaler with the smaller field of view and larger field of view.

c. Raw 40.96 second rate for each (of 10) housekeeping scaler.

d. Calculated 40.96 second electron rate.

For deck and offset detectors:

a. $\sin^2\alpha_B$, where α_B is the angle between the magnetic field and the detector axis once per major frame (40.96 seconds)

b. $\sin\phi\cos\theta$, where (ϕ, θ) are (zenith, azimuth, angles) defining the direction of the center of the Earth once per major frame (40.96 seconds)

Once per major frame:

a. McIlwain L parameter
b. Flag for Earth in field of view
c. Flag for moon in field of view
d. Flag for high voltage anomaly
e. Flag for block encoder error
f. Flag for electron contamination
g. Flag for "sunlit satellite"
h. Flag for South Atlantic Anomaly or North Pacific Anomaly
i. Flag for source in the field of view

2.2.2 XRATES Data Base

The XRATES data base is a condensed version of the MAX data base, containing mainly discovery scaler data and including several data quality flags not on the MAX data base (h, i, m, p, and q below). Each XRATES record corresponds to one MAX record and contains data that was accumulated in one major frame (40.96 seconds) except the digital status which completes a cycle in two major frames, and the analog status which completes a cycle in eight major frames. Only major frames that are not in engineering format are included. Major frames in RAM0 are not included. By setting a switch via input data, SLAP will include only clean major frames in XRATES. One XRATES major frame contains the following information:

a. Day and milliseconds of major frame
b. Electron contamination flag
c. High voltage flag
d. Spin axis index
e. Data format index
f. Major frame counter
g. Data quality flag
h. Clean flag (See Appendix B)
i. Super clean flag (See Appendix B)
j. High voltage anomaly flag
k. SAA-NPA/Sunlight flag
l. Jet firings
m. Source in field of view flag (See Appendix B)
n. Direction to center of the Earth in s/c coords (radians)
o. Earth occultation flags (with and without atmosphere)
p. Pointing flag (See Appendix B)
q. Digital status flag (See Appendix B)
r. Solar time (radians)

s. Geodetic longitude and latitude of s/c (radians)

t. Distance from s/c to Earth center (km.)

u. McIllwain L parameter

v. x, y, z components of magnetic field in s/c coords

w. x, y, z components of moon in s/c coords

x. Experiment status words

y. Digital status words

z. Analog status words

aa. Spin axis right ascension and declination

bb. Y-axis right ascension and declination

cc. Housekeeping scalers

dd. Discovery scalers

A more detailed description of the XRATES data base is given in Appendix A.

2.2.3 Experiment Status Log

The entire analog status is punched onto cards once per half day for production data and once per orbit for Quicklook data.

2.3 PROGRAM DESIGN

The overall structure of the program is shown in the Hierarchy diagram (Figure 2-2) and the routine cross-reference chart (Figure 2-3). All initialization of variables, reading of input variables, and setting up of selection switches based on the input data is done in subroutine INIT. The MAIN routine does all handling of the MAX input tape through FTIO routines MOUNT, POSN, FREAD, and UNLOAD. All major frames are processed through calls to PROG1 and DIGIT. PROG1 calculates the nominal spin position through a call to EPHEM, gets a list of the sources in the scan plane defined by that spin axis position via YSRCES, calls DAPRT to extract and analyze the digital and analog status, and punches the analog status on cards. DIGIT saves the digital status for the major frame.

All major frames not in format RAM0 are also processed through calls to CLEAN and PROG2. CLEAN checks to see that the general data quality is good. PROG2 sets the moon in field-of-view flag, the super clean flag, the source in-field-of-view flag, and spin axis flag by calls to MFOV, SCLEAN, PNTLOC, and SPFLAG, respectively, and sets up and writes the XRATES record corresponding to the current MAX record using the FTIO routine FWRITE. XREXT controls plotting. It first calls subroutines XRDISC, XRHOUS, and XRATT to save discovery scalers, housekeeping scalers, and attitude data in plotting arrays. When a revolution of the spacecraft is completed, XREXT calls XRPLOT to draw the plots via subroutines CPLOT, DOPLOT, DSPLOT, and HKPLOT. At the end of each file on the MAX tape, MAIN calls SUMOUT to end the file on the XRATES tape and calls XRPLOT to plot all the data that was saved, but not plotted yet.

The COMMON Block Usage Chart is shown in Figure 2-4. CURREC contains the current MAX major frame; TAPOUT contains the current XRATES major frame; PLTARR contains the arrays of data saved for plotting; PRTSW contains the processing selection switches; and SAVDIG contains the experiment digital status for five consecutive major frames (current and the two before and after).

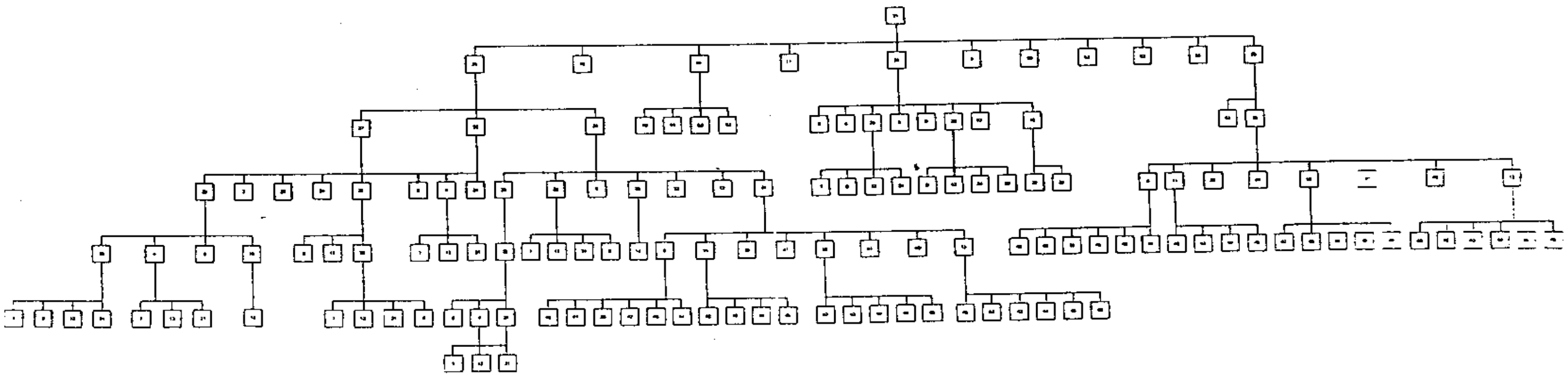


Figure 2-2. SLAP Hierarchy Diagram
Page 1 of 4

1.	ADDR	-	Obtains the address of common block HOLD
2.	CLEAN	-	Calculates data quality flags
3.	CONECL	-	Calculates ecliptic coordinates from celestial coordinates
4.	CONVEC	-	Converts from celestial coordinates to spacecraft coordinates
5.	CONVER	-	Converts celestial coordinates from 1978 Epoch to 1950 Epoch
6.	CPLOT	-	Plots data common to all the plots (i.e., plots the seven flags and the sources and prints the source names)
7.	CROSS	-	Calculates vector cross product
8.	CVXYZ	-	Converts ra and dec to Cartesian coordinates
9.	DAPRT	-	Extracts and analyzes the digital and analog status
10.	DIGIT	-	Saves the digital status for a major frame
11.	DOPLOT	-	Plots some of the attitude data
12.	DOT	-	Calculates vector dot product
13.	DSPLOT	-	Plots discovery scaler data
14.	ELCON	-	Calculates electron rate and error
15.	EPHEM	-	Calculates position of sun
16.	FOVIEW	-	Determines if a given location is within the field of view of given detector
17.	HEADER	-	Prints the MAX tape file header
18.	HKPLOT	-	Plots housekeeping scalers
19.	INIT	-	Initializes variables, reads input parameters and sets up processing selection switches
20.	JDAY	-	Calculates Julian day
21.	MAIN	-	Overall control of processing; mounts, positions and reads input MAX tape
22.	MFOV	-	Determines if the moon is in the field of view of any detector
23.	PNTLOC	-	Determined if a sky location is within the field of view of any detector

24. PROG1 - Transfers current record to common CURREC, finds sources in scan plane for current spin axis position, punches analog status cards.

25. PROG2 - Calls subroutines to process a major frame

26. SCANGL - Computes 32 scan angles for major frame

27. SCLEAN - Sets super clean flag

28. SPFLAG - Sets pointing flag

29. SUMOUT - Called at end-of-file on MAX tape. Writes end-of-file mark on XRATES tape, calls plotting routines, and reinitializes variables.

30. SUNMUN - Calculates position of sun

31. UNITV - Calculates unit vector for a three dimensional vector

32. XRATT - Saves attitude data and flags in plotting arrays

33. XRDISC - Saves Discovery Scaler data in plotting arrays

34. XREXT - Saves scan angles in plotting arrays and calls routines to save Discovery Scaler housekeeping, and attitude data, and calls the plotting routine when a set of detectors has completed a revolution

35. XRHOUS Saves housekeeping scalers and electron rate in plotting arrays

36. XRPLOT - Controls plotting of data

37. XRTAPE - Sets up and writes record for XRATES tape

38. YSRCES - Compiles a list of all sources in the scan plane of the spacecraft during one spin axis position

WOLFPLOT ROUTINES:

39. EDIT - Converts a number to a string of EBCDIC characters

40. ENDPLT - Terminates plot package

41. FRMADV - Terminates plotting of a frame and advances the frame

42. HORLIN - Writes a horizontal label on plots

43. OGRID - Draws a grid overlay with tick marks and sets scaling

44. PLOT - Plots an array of data

45. PLOTST - Initializes plot package

46. SETGRD - Defines boundaries of grids and object scaling

47.	SETSIZ	-	Sets size of characters for plot
48.	VERHST	-	Draws a vertical bar histogram
49.	VERLIN	-	Writes a vertical label on plots
	FTIO ROUTINES:		
50.	FREAD	-	Reads a logical record
51.	FWRITE	-	Writes a logical record
52.	MOUNT	-	Mounts a tape volume
53.	POSN	-	Positions a tape to a file
54.	REWIND	-	Positions a data set at beginning of volume
55.	UNLOAD	-	Unloads a tape volume

Calling Subprogram

Called Subprogram	CONVEC	CPLOT	DOPLOT	DSPLOT	EPHEM	FOVIEW	HKPLOT	INIT	MAIN	MFOV	PNTLOC	PROG1	PROG2	SCANGL	SPFLAG	SUMOUT	XRATT	XREXT	XRHOUS	XRPLOT	XRTAPE	YSRCES
ADDR																						
CLEAN									•													
CONECL												•									•	
CONVEC										•	•											
CONVER												•										
CPLOT																				•		
CROSS	•													•								
CVXYZ										•	•	•		•	•			•				•
DAPRT												•										
DIGIT									•													
DOPLOT																				•		
DOT	•					•						•		•	•			•				•
DSPLOT																				•		
ELCON																			•			
EPHEM												•										
FOVIEW											•											
HEADER									•													
HKPLOT																				•		
INIT									•													
JDAY					•																	
MFOV													•				•					
PNTLOC																					•	
PROG1									•													
PROG2									•													
SCANGL											•	•			•			•				
SCLEAN																					•	
SPFLAG																					•	
SUMOUT									•													
SUNMUN					•																	
UNITV	•									•				•								
XRATT																		•				
XRDISC																		•				
XREXT													•									
XRHOUS																		•				
XRPLOT																•		•				
XRTAPE													•									
YSRCES												•										
Wolfplot Routines																						
EDIT		•																		•		
ENDPLT								•														
FRMADV																				•		
HORLIN		•	•	•			•													•		
OGRID		•	•	•			•															
PLOT		•	•	•			•															
PLOTST								•														
SETGRD		•	•	•			•															
SETSIZ		•																		•		
VERHST				•																		
VERLIN				•			•															
FTIO Routines																						
FREAD									•													•
FWRITE																					•	
MOUNT								•	•													
POSN								•	•							•						
REWIND																						•
UNLOAD									•													

Figure 2-3 Subroutine Cross Reference

Used by Subprogram \ Common Block	ANGLES	BUFFER	CONST	CURREC	DATAR	DETCOM	ETCOM	FMOON	FOVCOM	HOLD	INPARM	PLTARR	PRINT	PRTSW	SAVDIG	SCACOM	SCLASS	SUMMY	SUMXR	TAPOUT	TOLER	XRFLAG
ADDR		●																				
CLEAN				●				●						●	●			●				
CONECL			●																			
CPLOT												●					●					
DAPRT																						
DIGIT															●							
DCPLOT												●										
DSPLOT												●										
ELCON				●																	●	
FOVIEW						●			●													
HEADER														●								
HKPLOT												●										
INIT		●	●							●	●			●	●			●	●		●	●
MAIN											●			●	●			●				
MFOV				●				●						●				●				
PNTLOC				●		●											●					
PROG1	●	●	●	●	●		●			●	●	●	●	●		●	●	●				●
PROG2								●						●								
SCANGL			●																			
SCLEAN				●				●						●	●							
SPFLAG				●																		
SUMOUT				●	●							●	●	●				●	●	●		
XRATT	●			●				●				●										
XRDISC	●			●								●		●								
XREXT	●			●							●	●						●				
XRHOUS	●			●								●		●								
XRPLOT	●		●								●	●						●				
XRTAPE				●				●			●			●	●			●	●	●		
YSRCES			●																			●

Figure 2-4 Common Block Cross-References

SECTION 3 - USER'S GUIDE

3.1 SYSTEM REQUIREMENTS

Program SLAP can be accessed and run on either the IBM 360/91 or 360/75 computer. It is run from two load modules: M2. ZBARS. SB018. SLAPLMOD (SLAPPLOT) and K3. ZBARS. SB018. STATLOAD(RAMLD) for the full version including plots, and M2. ZBARS. SB018. SLAPLMOD(SLAP) and K3. ZBARS. SB018. STATLOAD(RAMLD) for the version without plots.

The JCL necessary to run SLAP is stored in CRBE file ZB2SB(SLAP1). Two changes must be made to the JCL for the full version of SLAP:

(1) The volume serial numbers for the plot tapes are symbolic parameters on the EXEC card and are changed for each run

//STEP1 EXEC SLAP, PLTAP1=XR_______, PLTAP2=XR_______

(2) DD cards for both SD4060 and CalComp plot tapes are included in the JCL but only one may be used. An asterisk must be placed in the third column of the DD cards that are not necessary, and if an asterisk is in the third column of the desired DD cards it must be removed.

No changes to the JCL are necessary to run SLAP without plots.

The full version of SLAP requires approximately 550K bytes of core storage to execute. A run processing one Quicklook tape with 150 records takes approximately 2.8 minutes CPU time and 0.8 minutes I/O time (S/260-91). The version of SLAP without plots requires 300K bytes to execute.

3.2 INPUT DATA

Input to SLAP consists of a MAX tape, an X-ray source catalog, and a set of parameters to be read from cards.

The MAX tape is a 9-track, 6250 bpi, no label magnetic tape produced by program FRAPPE.

The X-ray source catalog is stored on disk with file name K3.ZBDFA. SB018.XRSRC.

Card input is as follows:

(1) The first data read in is the namelist CARDIN, which must have the following format. The first card must begin with ƀ&CARDINƀ followed by data items. The end of the namelist is signalled by ƀ&END. A data item consists of a variable name, followed by an equal sign, the value to be assigned to that variable, and a comma. The data items may appear in any order, and as many cards as necessary may be used, but each card must have a blank in column one. A description of the variables in namelist CARDIN follows:

Name	Type	Description and Default (if any)
DTAPE	R*8	Volume serial number of MAX tape (must be in quotes, e.g., DTAPE = 'XR0001')
NFILE	I*4	File number on MAX tape where processing begins Default: 1
IDAY1	I*4	Day of MAX tape where processing begins Default: 0 (beginning of file)
ITIM1	I*4	Time of milliseconds on MAX tape where processing begins Default: 0 (beginning of file)
IDAY2	I*4	Day on MAX tape where processing ends Default: 999 (end of tape)
ITIM2	I*4	Time in milliseconds on MAX tape where processing ends Default: 99999999 (end of tape)
QCLEAN	L*1	Write only 'clean' data to XRATES tape Default: True
IELECT	I*4	Method for electron rate calculation 1=default, 2=optional Default: 1

Name	Type	Description and Default (if any)
NSPIN	I*4	Number of spin axis overrides (which follow namelist data). Each override is associated with a MAX file if NSPIN ≠ 0; it must equal the number of MAX files to be processed
ISCLAS	I*4	X-ray source classification selection flag (all sources with class = ISCLAS are accepted. Default: 999 (all sources accepted)
QPLOT	L*1	Produce plots Default: True
IPLOTR	I*4	Plotting device(s) to be used in decimal digit form DCGSP P=0, no printer; =1, printer S=0 G=0 C=0, no CalComp; =2, 12" CalComp D=0, no SD4060; =1, SD4060 Default: 10000 (SD4060)
DTAPXR	R*8	Volume serial number of output XRATES tape (must be in quotes, e.g., DTAPR= 'XR0002')
NFILXR	I*4	XRATES file where processing begins Default: 1
QTAPE	L*1	Write XRATES tape Default: True

(2) Following the namelist input, the nominal spin axis position overrides are read in if NSPIN was greater than zero. These should appear one per card in the following format:

Columns 1-8	Right Ascension of spin axis in degrees (format F8.0)
Columns 9-16	Declination of spin axis in degrees (format F8.0)

The first spin override card will be associated with the first MAX file read (NFILE); the next MAX file will use the next spin override, etc. There must be NSPIN spin override cards.

If more intervals of data are to be processed, the entire sequence of input data (namelist and spin override cards) may be repeated as many times as desired.

3.3 OUTPUT DATA

Output from SLAP includes a printout with a listing of the digital and analog status, punched cards giving analog status, an optional XRATES tape, and an optional plot tape.

3.3.1 Printout

At the beginning of processing for a volume, the user input parameters are echo printed and the sources in the field of view are listed. For each file (quicklook) or tape (production), the digital status is printed at the end of the first complete digital cycle and whenever there is a change in the digital status thereafter, and the analog status is printed at the end of the first complete analog cycle. At the end of each interval processed, SLAP writes the message 'END OF INTERVAL' and gives the end time and number of major frames processed. At the end of each file, SLAP writes the message 'END OF MAX FILE XX', and gives the number of major frames processed. At the end of a volume, SLAP writes the message 'END OF MAX VOLUME XR________'. If the job terminates normally, SLAP writes the message 'END OF XRATES VOLUME XR________', and the XRATES volume number, file number, number of records, and number of I/O errors, and finally the message 'PROCESSING OF MAX VOLUMES COMPLETED'.

3.3.2 Cards

For each file (quicklook) or tape (production), the analog status is punched onto cards after a complete analog cycle. On the first card a heading is printed giving the time: 'HEAO-A2 ANALOG DATA FOR DAY xxx MILLISECSyyy'. On the succeeding 32 cards, the 256 words of analog status are printed in the format 8F10.3.

3.3.3 XRATES Tape

The XRATES tape is a no-label, 9-track density-3 tape. For each record on the MAX tape that passes a clean test and is not in engineering format, a record will be written on the XRATES tape with the information described in Section 2.2.2.

3.3.4 Plots

SLAP produces plots on the line printer and/or on plot tape (CalComp or SD4060 microfilm) at the option of the user. For CalComp, the plot tape is labeled as a 7-track, density-1, NL tape. For SD4060, the plot tape is labeled as a 9-track, density-3, NL tape. The plots are described in Section 2.2.1.

3.4 ERROR MESSAGES

'ERROR IN NUMBER OF OVERRIDES' (written by INIT)
If the sum of NSPIN and NFILE is greater than 20, the program stops (there is space to store only 20 spin overrides).

'TIME INTERVAL ERROR: DAY OR TIME TOO LARGE' (written by INIT)
If the start day is greater than 366, the start milliseconds is greater than 86400000, or the start day and end day are both zero, the program stops.

'I/O ERROR ON RECORD xx FILE NUMBER yy MAX VOLUME zz'
(written by MAIN) If there have been less than 10 I/O errors on the input tape, the faulty record is skipped and processing continues with the next record. When 10 I/O errors have been encountered, the program stops.

'ERROR READING X-RAY SOURCE DISK FILE' (written by YSRCES)
Reading of the source catalog is stopped and the program continues.

'***TOO MANY SOURCES *** NAME DELETED=XXX AT RT.ASC. & DEC.
XX XX, RADIANS XX # OF SOURCES XX' (written by YSRCES)

There is space to store only 50 sources. If more than 50 are in the field of view, the extra are ignored and processing continues.

3.5 JCL

The following is an example of the JCL and data for a run:

```
//SLAP PROC   PLTAP1=XXXXXX,PLTAP2=YYYYYY
//GO EXEC PGM=LINKER,PARM='MAP,CALL,TERM,EP=MAIN,SIZE=300K',
//            REGION=300K,COND=(4,LT)
//SYSLIB DD DSN=SYS2.WOLFPLOT,DISP=SHR
//          DD DSN=SYS1.FORTLIB,DISP=SHR
//          DD DSN=SYS2.FORTLIB,DISP=SHR
//          DD DSN=SYS1.FORTSSP,DISP=SHR
//SYSLOUT DD SYSOUT=A,DCB=(RECFM=FBSA,LRECL=121,BLKSIZE=3509,BUFNO=1)
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265,BUFNO=1),
//                SPACE=(CYL,(0,1)),UNIT=(DISK,3)
//SYSTERM DD SYSOUT=A
//SYSUDUMP DD SYSOUT=A
//SYSLIN DD DSN=M2.ZBARS.SB018.SLAPLMOD(SLAP),DISP=SHR
//          DD DSN=K3.ZBARS.SB018.STATLOAD(RAMLD),DISP=SHR
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(BLKSIZE=7265,LRECL=137,RECFM=VBA,BUFNO=1),
//                SPACE=(CYL,(5,1))
//FT07F001 DD SYSOUT=B,DCB=(BLKSIZE=7280,LRECL=80,RECFM=FB,BUFNO=1)
//FT10F001 DD UNIT=(1600,,DEFER),LABEL=(,NL),DISP=(OLD,KEEP),
//                DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,BUFNO=1,DEN=3),
//                VOL=SER=DTAPE
//FT11F001 DD DSN=K3.ZBDFA.SB018.XRSRC,DISP=SHR,DCB=(BUFNO=1)
//FT20F001 DD UNIT=(1600,,DEFER),LABEL=(1,NL),DISP=(OLD,KEEP),
//                DCB=(RECFM=FB,LRECL=5048,BLKSIZE=5048,BUFNO=1,DEN=3),
//                VOL=SER=DTAPXR
//*PLOTTAPE DD DCB=DEN=1,LABEL=(,NL),UNIT=(7TRACK,,DEFER),
//*    VOL=SER=(&PLTAP1,&PLTAP2)
//WOLF4060 DD DCB=DEN=3,LABEL=(1,BLP,,OUT),UNIT=(9TRACK,,DEFER),
//      VOL=SER=(&PLTAP1,&PLTAP2)
//ENDPROC PEND
//STEP1 EXEC SLAP,PLTAP1=XXXXXX
//DATA5 DD *,DCB=(BUFNO=1)

 &CARDIN DTAPE='XR0285',QPLOT=.FALSE.,DTAPXR='XR0237',ISCLAS=1, &END
 &CARDIN DTAPE='XR0286',QPLOT=.FALSE.,DTAPXR='XR0237',ISCLAS=1, &END
 &CARDIN DTAPE='XR0287',QPLOT=.FALSE.,DTAPXR='XR0237',ISCLAS=1, &END
 &CARDIN DTAPE='XR0288',QPLOT=.FALSE.,DTAPXR='XR0237',ISCLAS=1, &END
 &CARDIN DTAPE='XR0289',QPLOT=.FALSE.,DTAPXR='XR0237',ISCLAS=1, &END
```

APPENDIX A

XRATES DATA BASE

INTRODUCTION

The XRATES data base is a condensed version of the MAX data base containing mainly discovery scaler data. Only major frames from MAX that are not in engineering format are included. Each XRATES physical record contains data that was accumulated in one major frame (40.96 seconds) except the digital status which completes a cycle in two major frames, and the analog status which completes a cycle in eight major frames.

TAPE CHARACTERISTICS

Tape Attributes:

9-track, 1600 bpi

File Structure:

Each XRATES file corresponds to one MAX file. There are varying numbers of files per tape depending on the length of the interval selected when creating the XRATES tape.

Quicklook: Each file represents a maximum of one orbit.

Production: Each file represents a maximum of 12 hours.

Record Format:

Fixed length, blocked.

RECEM=FB, LRECL=5048, BLKSIZE=5048.

DATA QUALITY

There are three checks made on the quality of data. A block encoder error indicates a transmission error from s/c to ground. A bit error indicates one or more bits within a minor frame has been improperly received. Fill data indicates data for that minor frame is missing. An overall data quality flag

(HQUAL) is set to indicate if there were any block encoder errors, bit errors, or fill data anywhere in a major frame. Additionally, the data itself is made negative if there were bit errors, and the data is replaced with hexadecimal 'AAAA' if there was fill data.

COMMON BLOCK DESCRIPTION

The COMMON Block TAPOUT can be used to reference the XRATES data base. A description of the variables follows:

Variable	Type	Description
MFDAY	I*4	Day of major frame
MSEC	I*4	Millisecond of major frame
HECON	I*2	Electron contamination flag 2**1, 2**0 = LED1 limit=600 2**3, 2**2 = LED2 limit=600 2**5, 2**4 = HED1 limit=1000 2**7, 2**6 = HED2 limit=700 2**9, 2**8 = MED limit=600 2**11, 2**10 = HED3 limit=500 bits=00=electron rate .le. limit bits=11=electron rate .gt. limit
HVF	I*2	High voltage flag 2**0 = LED1 2**1 = LED2 2**2 = HED1 2**3 = HED2 2**4 = MED 2**5 = HED3 bit=0=high voltage on and not within two frames of turn on bit=1=high voltage off or within two frames of turn on
HSPAX	I*2	Spin axis index (1-720) Spin circle is divided into 720 1/2 degree bins

Variable	Type	Description
HFRM	I*2	Data format index If in ROM, = ROM number If in RAM, = RAM number +10
HMF	I*2	Major frame counter
HQUAL	I*2	Overall data quality flag 2**0 = block encoder error 2**1 = bit error 2**2 = fill data bit=0=no error, bit=1=error
HCL	I*2	Clean flag 2**0 = LED1 2**1 = LED2 etc. bit=0=not clean bit=1=clean
HSUPCL	I*2	Superclean flag 2**0 = LED1 2**1 = LED2 etc. bit=0=not super clean bit=1= super clean
HVANOM	I*2	High voltage anomaly flag 2**0 = LED1 2**1 = LED2 etc. bit=0=stable bit=1=unstable
HASUN	I*2	SAA/NPA anomaly flag - also sunlight flag 2**0 = SAA/NPA bit=0=no SAA/NPA bit=1=SAA/NPA 2**1 = sunlight bit=0 no sunlight bit=1=sunlight
HJET	I*2	Number of jet firings during major frame

Variable	Type	Description
HSFOV	I*2	Source in field of view flag 2**0 = LED1 2**1 = LED2 etc. bit = 0 = no source in field of view bit = 1 = source in field of view
THETA	R*4	Rotation angle from S/C y axis about S/C z axis to center of earth ($-\pi$ to $+\pi$)
PHI	R*4	Angle from S/C z axis to center of earth (0 to π)
HEAR1	I*2	Earth occultation flag (not including atmosphere) 2**0 = LED1 2**1 = LED2 etc. bit = 0 = no occultation bit = 1 = occultation
HEAR2	I*2	Earth occultation flag (including atmos.) 2**0 = LED1 2**1 = LED2 etc. bit = 0 = no occultation bit = 1 = occultation
HPT	I*2	Spin axis flag 2**0 bit = 0 spin period nominal = 1 spin period not nominal 2**1 bit = 0 spin axis is within 2 degrees of sun = 1 spin axis is not within 2 degrees of sun.
HDIG	I*2	Digital status flag 2**1, 2**0 = LED1 2**3, 2**2 = LED2 etc. bit = 0: no change, bit = 1 changing where the two bits per detector represent: LSB - memory format and/or DPU MSB - experiment or detector digital status

Variable	Type	Description
STIME	R*4	Solar time (radians)
GLON	R*4	Geodetic longitude and latitude of
GLAT	R*4	s/c (radians)
ECNTR	R*4	Distance from s/c earth center (km.)
AMACL	R*4	McIllwain L parameter
XB	R*4	x, y, z components of magnetic field in
YB	R*4	s/c coordinates
ZB	R*4	
XM	R*4	x, y, z components of moon position in
YM	R*4	s/c coordinates
ZM	R*4	
QSTATE (25)	L*1	Experiment status words
QSTATD (13, 6)	L*1	Digital status words for 6 detectors
QSTAT (32, 8)	L*1	Analog status words
SARA (32)	R*4	Spin axis right ascension (radians)
SADEC (32)	R*4	Spin axis declination (radians)
YARA (32)	R*4	Y axis right ascension (radians)
YADEC (32)	R*4	Y axis declination (radians)
IHOUS (10, 6)	I*4	Housekeeping scalers (10 scalers, 6 dets)
HDISC (40, 8, 6)	I*2	Discovery scalers (40 lsb's and sums, 8 scalers, 6 dets)

CATALOG DESCRIPTION

A catalog is kept for the XRATES tapes storing the tape number, file number, orbit and time range of the data. When an XRATES tape has been brought back for storage, the tape number will be blank.

The catalog can be accessed from TSO or CRBE.

XRATES Quicklook:

From TSO: qed 'zbfll.heaotape.list

From CRBE: b d-ZB2SB.heaotape.list(rodctlg)

XRATES Production:

From TSO: qed 'ZB25S.heaotape.list(prodctlg)'

From CRBE: b D-ZB2SB.heaotape.list(prodctlg)

XRATES FORMAT

	4		8		12		16
Day Number		Milliseconds of Day		Electron Cont. Flag	H. V. Flag	Spin Axis Index	Data Format Index
Major Frame Counter	Data Quality Flag	Clean Flag	S. Clean Flag	H. V. Anomaly Flag	SAA/NPA Sunlight Flag	Jet Firings	Source in FOV Flag
(S/C Coord.) (Radians)		(S/C Coord.) (Radians)		Earth Occ. Flag I	Earth Occ. Flag II	Pointing Flag	Digital Status Flag
Solat Time (Radians)		S/C Longitude (Radians)		S/C Latitude (Radians)		S/C to Earth Center (Km)	
McIllwain L Value		B_x (S/C Coord.)		B_y (S/C Coord.)		B_z (S/C Coord.)	
$Moon_x$ (S/C Coord.)		$Moon_y$ (S/C Coord.)		$Moon_z$ (S/C Coord.)		Spare	

Current Experiment Digital Status (25 Bytes + 13 Bytes Per Detector + Spare = 104 Bytes)

DET 1

DET 2

DET 3

DET 4

DET 5

DET 6

Spare | Current Analog Status (256 Bytes)

1

2

256

3

4

5

6

7

8

32 R*4 — Spin Axis Right Ascension (Radians)

512

32 R*4 — Spin Axis Declination (Radians)

32 R*4 — Y Axis Right Ascension (Radians)

768

848

32 R*4 — Y Axis Declination (Radians)

Detector 1 Housekeeping Scalers — 10 Integer * 4

1024

Detector 2 Housekeeping Scalers

Detector 3 Housekeeping Scalers

Detector 4 Housekeeping Scalers

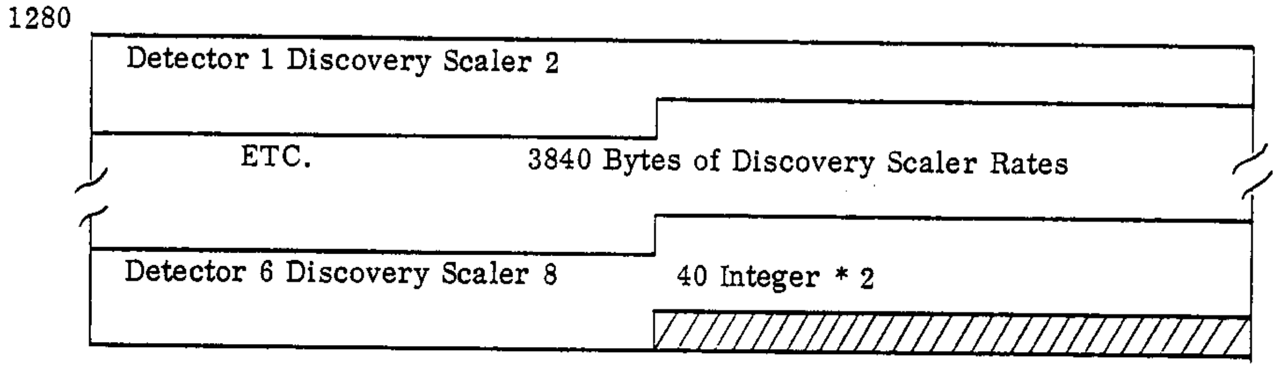
Detector 5 Housekeeping Scalers

Detector 6 Housekeeping Scalers

Detector 1 Discovery Scaler 1 — 40 Integer * 2

same order as MAX

1280



Length of Record 5048 Bytes

APPENDIX B - DATA QUALITY FLAG DEFINITION

SLAP calculates a set of standard data quality flags for use in data selection. These flags are then placed in the output record as indicated in Appendix A. The definition of these flags is as follows:

(1) Clean Flag

Clean data is defined for each detector to be:

(a) Detector field of view excludes the Earth +100 km for all detectors (test flag HEOCC2).

(b) Detector high voltage is stable. The high voltage must be on (test flag HVFLAG) and be changing by less than 2.0 volts over the three major frames centered on the present data (test flag HVST).

(c) There are no data transmission errors. This includes FILL data (except when due to ROM/RAM toggle), IPD bit errors, and block encoder errors (test HQUAL).

(d) Calibration source is not in field of view for LEDs and MED (test digital status).

Clean Flag is defined for each detector:

2**0 = LED 1

2**1 = LED 2

2**2 = HED 1

2**3 = HED 2

2**4 = MED

2**5 = HED 3

where: bit = 1 = clean

bit = 0 = not clean

(2) Superclean Flag

Superclean data is defined for each detector to be:

(a) Detector data is CLEAN.

(b) Detector field of view excludes the moon.

(c) Field of view excludes the Earth plus 100 km (test flag HEOCC2).

(d) All 1.28 second Discovery Scaler rates are less than 256, i.e., no LSB overflows.

(e) Rate in the first four Discovery Scalers are constant as determined by the following criteria:

(i) For each 1.28 second sample, add first four Discovery Scalers.

(ii) For 32 entries, calculate the actual variance, μ_2, and the statistical variance, $\sigma^2 = N$ (1.28 sec.).

(iii) Data is constant if $\mu_2 < 1.3(\sigma^2)$.

Superclean Flag is defined for each detector:

2**0 = LED 1

2**1 = LED 2

2**2 = HED 1

2**3 = HED 2

2**4 = MED

2**5 = HED 3

where bit = 1 = superclean
bit = 0 = not superclean

(3) Changing Digital Status Flag

The digital status is unchanged for each detector if:

(a) The memory format and/or the DPU status have not changed during this major frame.

(b) The experiment or detector status has not changed during the accumulation of data for this major frame.

The digital status flag is defined to be:

2**1, 2**0 = LED 1

2**3, 2**2 = LED 2

2**5, 2**4 = HED 1

2**7, 2**6 = HED 2

2**9, 2**8 = MED

2**11, 2**10 = HED 3

where the two bits per detector represent:

LSB represents memory format and/or dpu status (#1 above).

bit = 0 = no change

bit = 1 = changing

MSB represents experiment or detector status (#2 above).

bit = 0 = no change

bit = 1 = changing

(4) Pointing Flag

The spacecraft is defined to be in nominal mode if:

(a) The spin period is in the range 25-45 minutes. The spin period is calculated once per major frame.

(b) The spin axis is within 2 degrees of the sun. The nominal spin position is calculated once per MAX file. The spin axis is calculated once per major frame and compared to the nominal.

The pointing flag is defined to be:

2**0 = spin period

where:

bit = 0 = nominal

bit = 1 = pointing

2**1 = spin axis

where:

bit = 0 = nominal

bit = 1 = offset

(5) Source in Field of View Flag

The flag is set if any catalogued source is in the detector Large Field of View for any portion of the major frame.

The two byte flag is defined to be:

2**0 = LED 1

2**1 = LED 2

2**2 = HED 1

2**3 = HED 2

2**4 = MED

2**5 = HED 3

where:

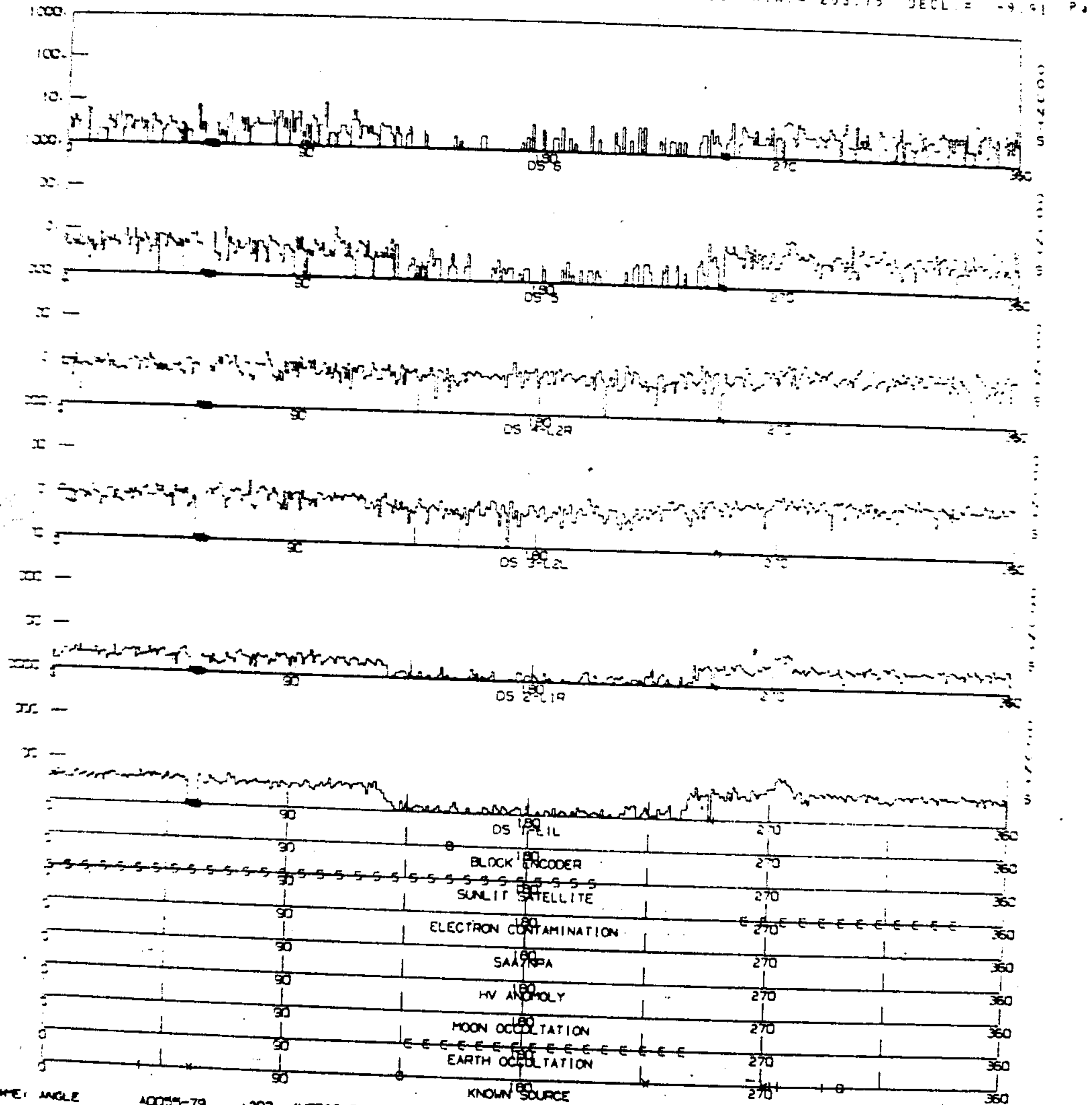
bit = 0 = no source

bit = 1 = source observed

APPENDIX C - SLAP PLOTS

The following is an example of a complete set of plots produced by SLAP for one complete rotation of the detector axis for one of the six detectors.

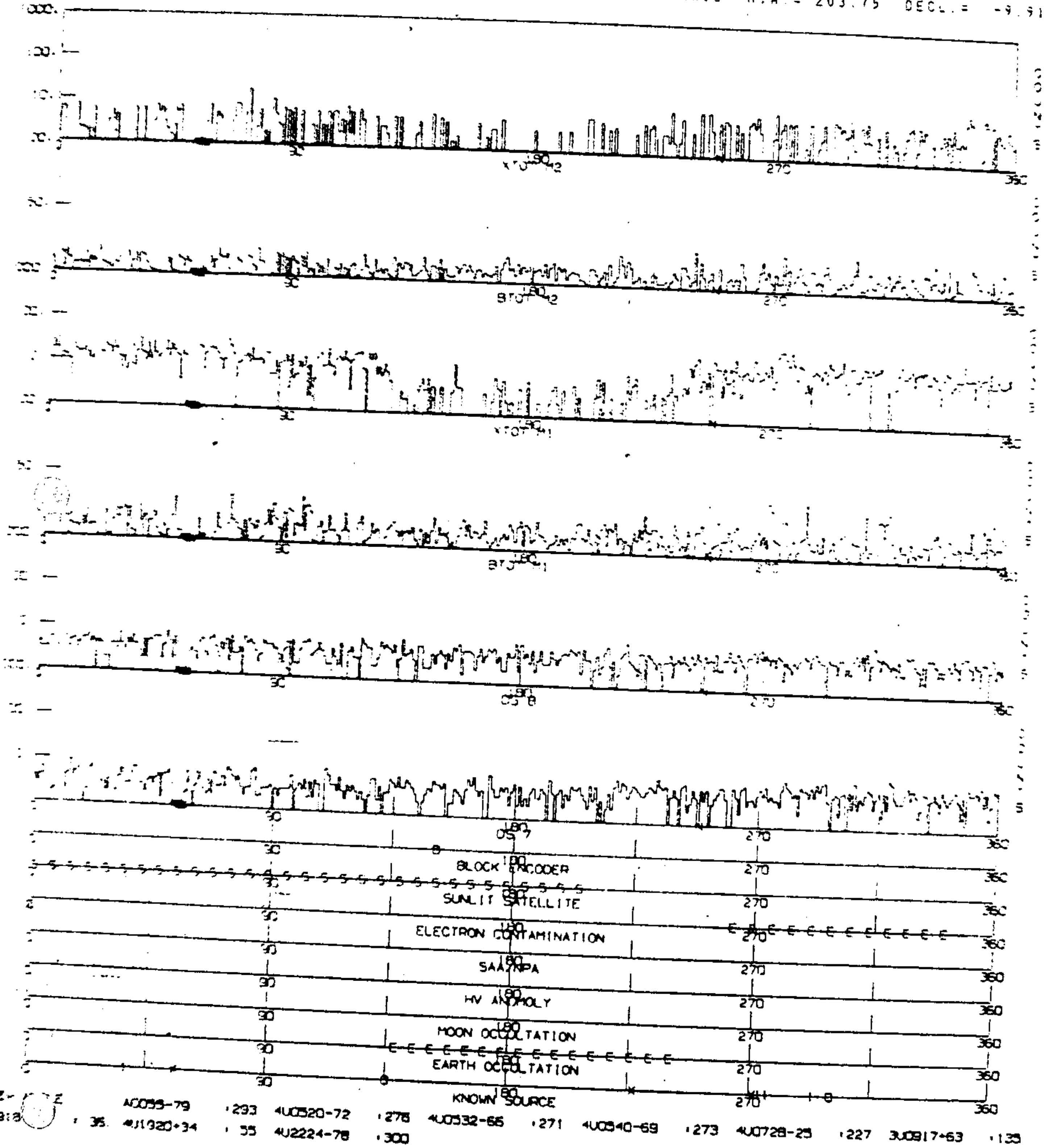
DETECTOR HED 3 DAY 292 SEC 45027 SPIN AXIS R.A. = 203.75 DECL. = -9.91



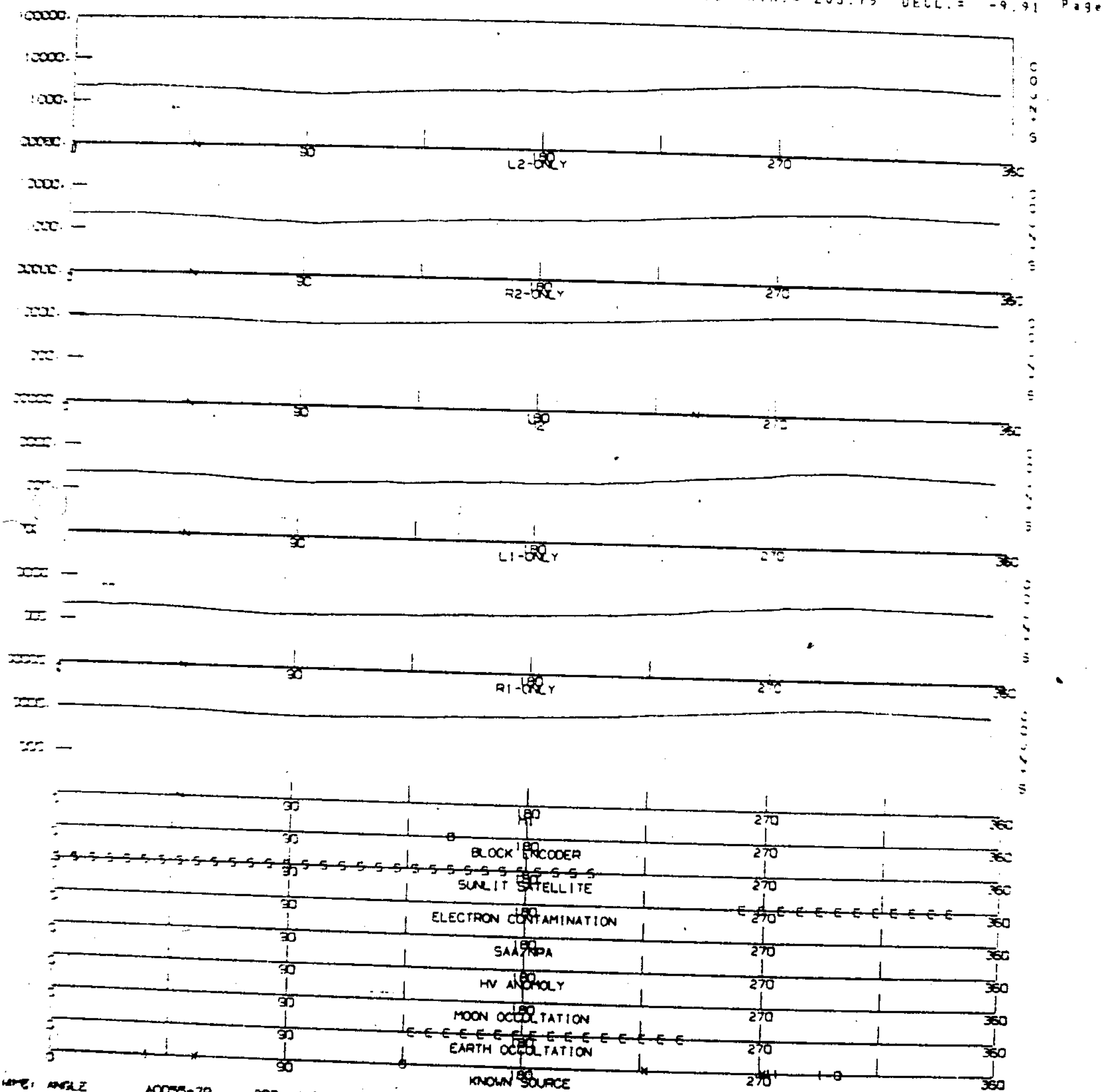
NAME ANGLE A0055-79 293 4U0520-72 276 4U0532-66 271 4U0540-69 273 4U0728-25 227 3U0917+63 135

18+15 36 4U1920+34 55 4U2224-78 300

DETECTOR HED 3 DAY 292 SEC 45027 SPIN AXIS R.A. = 203.75 DECL. = -9.91 Page

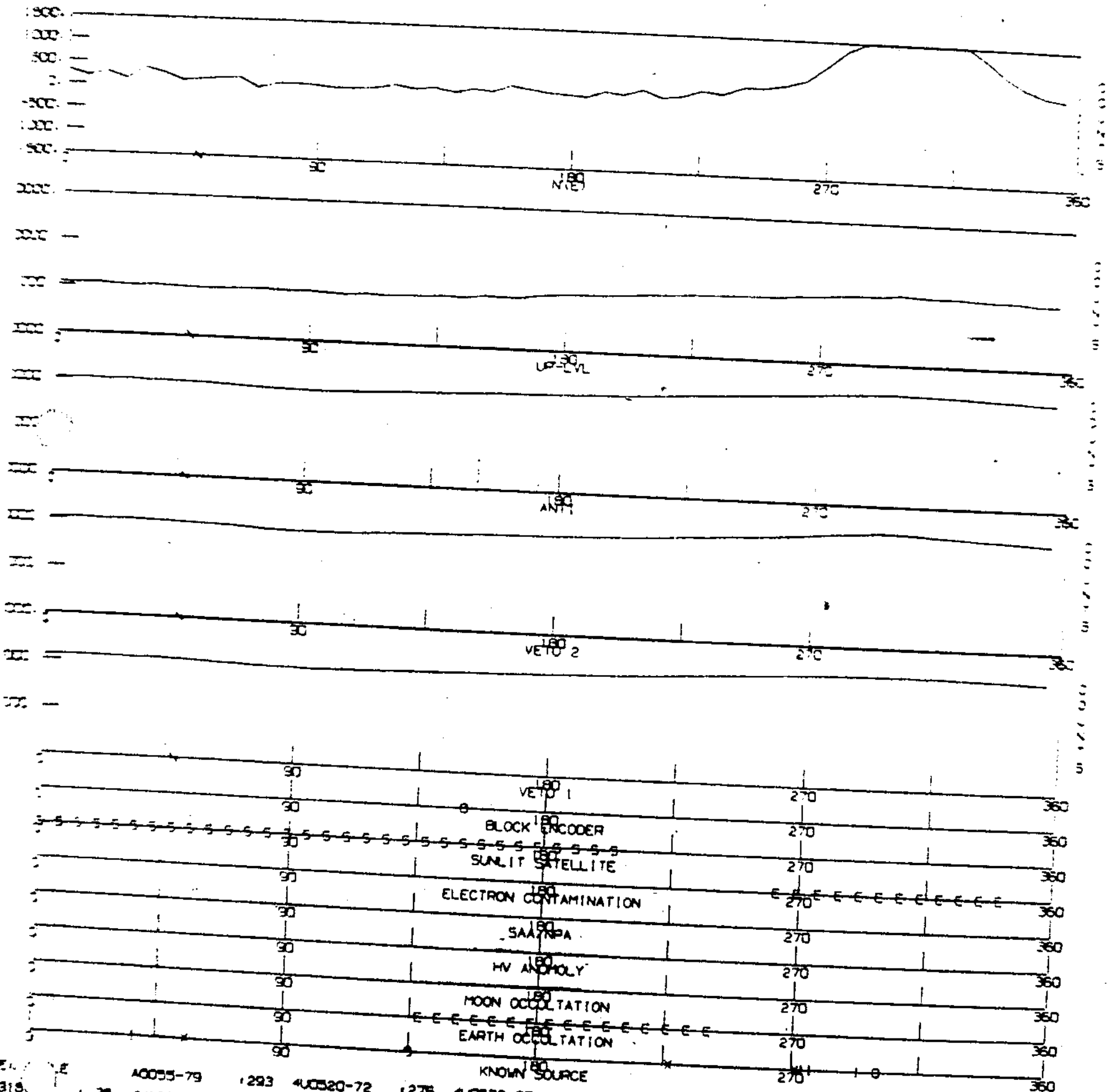


DETECTOR HED 3 DAY 292 SEC 45027 SPIN AXIS R.A.= 203.75 DECL.= -9.91 Page



NAME, ANGLE A0055-79 ,293 4U0520-72 ,278 4U0532-66 ,271 4U0540-69 ,273 4U0728-25 ,227 3U0917-63 ,135
4U1[illegible]5 , 38 4U1920-34 , 55 4U2224-78 ,300

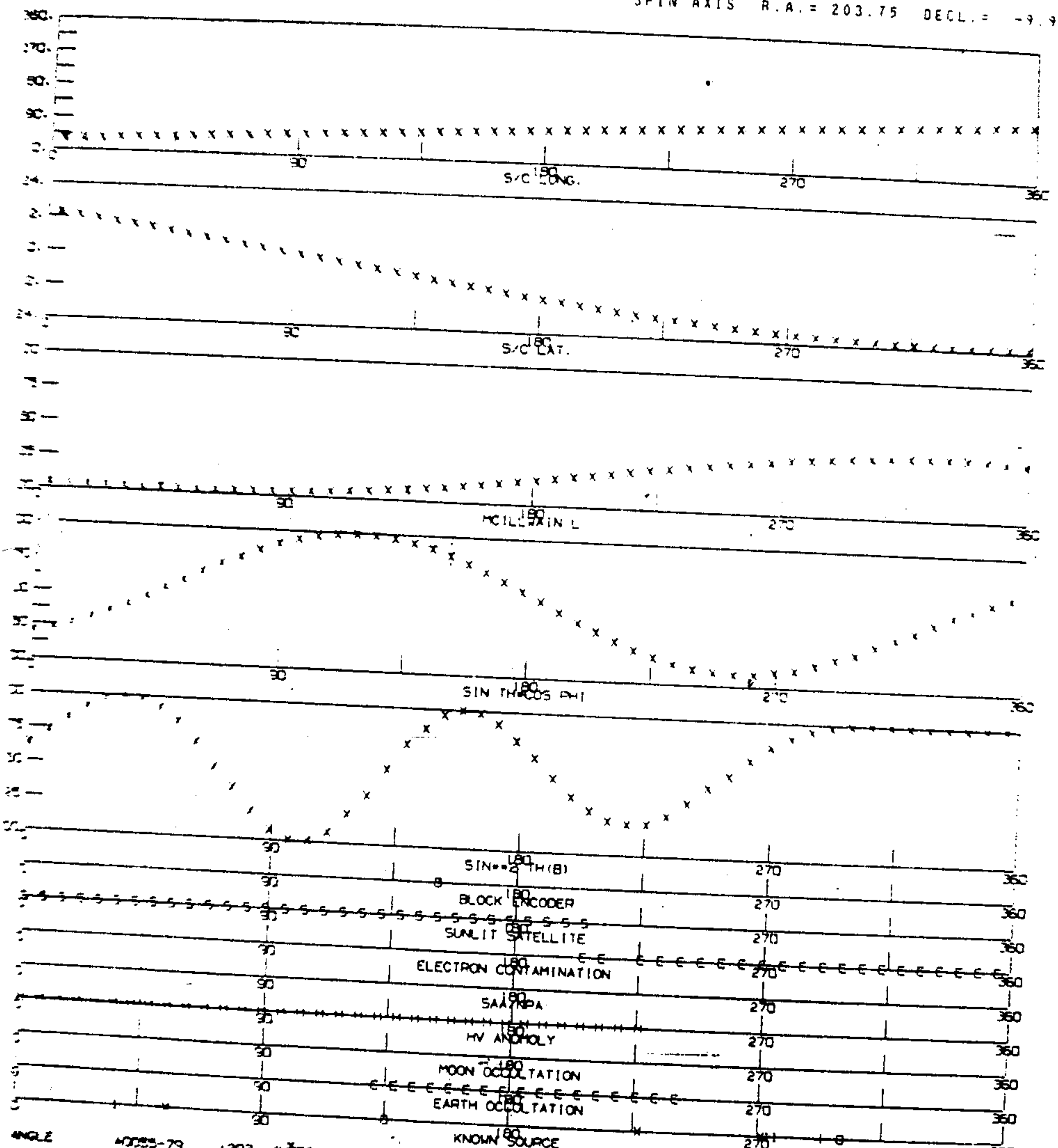
DETECTOR HED 3   DAY 292   SEC 45027   SPIN AXIS R.A.= 203.75 DECL.= -9.91 Page



A0055-79 ·293 4U0520-72 ·276 4U0532-66 ·271 4U0540-69 ·273 4U0728-25 ·227 3U0917-63 ·135

1918 ·38 4U1320+34 ·55 4U2224-78 ·300

DETECTOR DECK DAY 292 SEC 45027 SPIN AXIS R.A.= 203.75 DECL.= -9.91 Page



ANGLE 4U0055-79 293 4U0520-72 276 4U0532-66 271 4U0540-69 273 4U0728-25 227 3U0917+63 135
36 4U1920+34 55 4U2224-78 300

CSC

COMPUTER SCIENCES CORPORATION

Major Offices and Facilities Throughout the World

HEAO-1

A-2 MAX DATABASE

77-075A-02N

This data set consists of 126 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on an IBM computer. D101297, D101335, & D101369 were bad tapes. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101246	C-032176	14	08/14/77 - 08/17/77
D-101247	C-032177	9	08/18/77 - 08/21/77
D-101248	C-032178	11	08/22/77 - 08/25/77
D-101249	C-032179	14	08/26/77 - 08/29/77
D-101250	C-032180	15	08/30/77 - 09/02/77
D-101251	C-032181	15	09/03/77 - 09/06/77
D-101252	C-032182	19	09/07/77 - 09/10/77
D-101253	C-032183	15	09/11/77 - 09/15/77
D-101254	C-032184	14	09/15/77 - 09/18/77
D-101255	C-032185	9	09/19/77 - 09/23/77
D-101256	C-032186	9	09/23/77 - 09/26/77
D-101257	C-032187	10	09/27/77 - 09/30/77
D-101258	C-032188	8	10/01/77 - 10/04/77
D-101259	C-032189	12	10/05/77 - 10/08/77
D-101260	C-032190	9	10/09/77 - 10/12/77
D-101261	C-032191	9	10/13/77 - 10/16/77
D-101262	C-032192	10	10/17/77 - 10/20/77
D-101263	C-032193	13	10/21/77 - 10/24/77
D-101264	C-032194	11	10/25/77 - 10/28/77
D-101265	C-032195	8	10/29/77 - 11/01/77
D-101266	C-032196	12	11/02/77 - 11/05/77
D-101267	C-032197	8	11/06/77 - 11/09/77
D-101268	C-032198	17	11/10/77 - 11/13/77
D-101269	C-032199	8	11/14/77 - 11/17/77
D-101270	C-032200	11	11/18/77 - 11/21/77
D-101271	C-032201	10	11/22/77 - 11/25/77
D-101273	C-032203	9	11/26/77 - 11/29/77
D-101272	C-032202	10	11/30/77 - 12/03/77
D-101274	C-032204	11	12/04/77 - 12/07/77
D-101275	C-032205	11	12/08/77 - 12/11/77
D-101276	C-032206	10	12/12/77 - 12/15/77
D-101277	C-032207	8	12/16/77 - 12/19/77
D-101278	C-032208	11	12/20/77 - 12/23/77
D-101279	C-032209	9	12/24/77 - 12/27/77
D-101280	C-032210	10	12/28/77 - 12/31/77
D-101281	C-032211	12	01/01/78 - 01/04/78
D-101282	C-032212	8	01/05/78 - 01/08/78
D-101283	C-032213	8	01/09/78 - 01/12/78
D-101284	C-032214	9	01/13/78 - 01/16/78

D-101285	C-032215	9	01/17/78 - 01/20/78
D-101286	C-032216	10	01/21/78 - 01/25/78
D-101287	C-032217	10	01/26/78 - 01/28/78
D-101288	C-032218	10	01/29/78 - 02/02/78
D-101289	C-032219	9	02/02/78 - 02/05/78
D-101290	C-032220	8	02/06/78 - 02/09/78
D-101291	C-032221	10	02/10/78 - 02/13/78
D-101292	C-032222	10	02/14/78 - 02/17/78
D-101293	C-032223	10	02/18/78 - 02/21/78
D-101294	C-032224	10	02/22/78 - 02/25/78
D-101295	C-032225	11	02/26/78 - 03/01/78
D-101296	C-032226	13	03/02/78 - 03/05/78
D-101298	C-032227	9	03/10/78 - 03/13/78
D-101299	C-032228	11	03/14/78 - 03/17/78
D-101300	C-032229	10	03/17/78 - 03/21/78
D-101301	C-032230	12	03/22/78 - 03/25/78
D-101302	C-032231	9	03/26/78 - 03/29/78
D-101303	C-032232	11	03/30/78 - 04/02/78
D-101304	C-032233	8	04/03/78 - 04/06/78
D-101305	C-032234	11	04/07/78 - 04/10/78
D-101306	C-032235	11	04/11/78 - 04/14/78
D-101307	C-032236	10	04/15/78 - 04/18/78
D-101308	C-032237	9	04/19/78 - 04/22/78
D-101309	C-032238	10	04/23/78 - 04/26/78
D-101310	C-032239	10	04/27/78 - 04/30/78
D-101311	C-032240	11	05/01/78 - 05/04/78
D-101312	C-032241	11	05/05/78 - 05/08/78
D-101313	C-032242	10	05/09/78 - 05/12/78
D-101314	C-032243	10	05/13/78 - 05/16/78
D-101315	C-032244	9	05/17/78 - 05/20/78
D-101316	C-032245	9	05/21/78 - 05/24/78
D-101317	C-032246	9	05/25/78 - 05/28/78
D-101318	C-032247	11	05/29/78 - 06/01/78
D-101319	C-032248	11	06/02/78 - 06/05/78
D-101320	C-032249	14	06/06/78 - 06/09/78
D-101321	C-032250	8	06/10/78 - 06/13/78
D-101322	C-032251	12	06/14/78 - 06/17/78
D-101323	C-032252	8	06/18/78 - 06/21/78
D-101324	C-032253	12	06/22/78 - 06/25/78
D-101325	C-032254	11	06/26/78 - 06/29/78
D-101326	C-032255	9	06/30/78 - 07/03/78
D-101327	C-032256	10	07/04/78 - 07/07/78
D-101328	C-032257	11	07/08/78 - 07/11/78
D-101329	C-032258	10	07/12/78 - 07/15/78
D-101330	C-032259	10	07/16/78 - 07/19/78
D-101331	C-032260	12	07/20/78 - 07/23/78
D-101332	C-032261	13	07/24/78 - 07/27/78
D-101333	C-032262	11	07/28/78 - 08/01/78
D-101334	C-032263	9	08/02/78 - 08/04/78
D-101336	C-032264	10	08/09/78 - 08/12/78
D-101337	C-032265	12	08/13/78 - 08/16/78
D-101338	C-032266	13	08/17/78 - 08/20/78
D-101339	C-032267	11	08/21/78 - 08/24/78
D-101340	C-032268	12	08/25/78 - 08/28/78
D-101341	C-032269	9	08/29/78 - 09/01/78
D-101342	C-032270	10	09/02/78 - 09/05/78
D-101343	C-032271	9	09/06/78 - 09/09/78
D-101344	C-032272	8	09/10/78 - 09/13/78
D-101345	C-032273	10	09/14/78 - 09/17/78

D-101346	C-032274	16	09/18/78 - 09/21/78
D-101347	C-032275	14	09/22/78 - 09/25/78
D-101348	C-032276	10	09/26/78 - 09/29/78
D-101349	C-032277	10	09/30/78 - 10/03/78
D-101350	C-032278	13	10/04/78 - 10/07/78
D-101351	C-032279	17	10/08/78 - 10/11/78
D-101352	C-032280	11	10/12/78 - 10/15/78
D-101353	C-032281	13	10/16/78 - 10/19/78
D-101354	C-032282	16	10/20/78 - 10/23/78
D-101355	C-032283	14	10/24/78 - 10/27/78
D-101356	C-032284	13	10/28/78 - 10/31/78
D-101357	C-032285	12	11/01/78 - 11/04/78
D-101358	C-032286	10	11/05/78 - 11/08/78
D-101359	C-032287	9	11/09/78 - 11/12/78
D-101360	C-032288	11	11/13/78 - 11/16/78
D-101361	C-032289	10	11/17/78 - 11/20/78
D-101362	C-032290	17	11/21/78 - 11/24/78
D-101363	C-032291	15	11/25/78 - 11/28/78
D-101364	C-032292	19	11/29/78 - 12/02/78
D-101365	C-032293	14	12/03/78 - 12/06/78
D-101366	C-032294	10	12/07/78 - 12/10/78
D-101367	C-032295	9	12/11/78 - 12/14/78
D-101368	C-032296	14	12/15/78 - 12/18/78
D-101370	C-032297	13	12/23/78 - 12/26/78
D-101371	C-032298	9	12/27/78 - 12/30/78
D-101372	C-032299	15	12/31/78 - 01/03/79
D-101373	C-032300	18	01/04/79 - 01/07/79
D-101374	C-032301	9	01/08/79 - 01/10/79

77-075A-02N

CSC/TM-80/6044

HIGH ENERGY ASTRONOMY OBSERVATORY SATELLITE A (HEAO-A2) SLAP PROGRAM DESCRIPTION AND OPERATORS GUIDE

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-24350
Task Assignment 604

JUNE 1980

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-81/6217

HIGH ENERGY ASTRONOMY OBSERVATORY-A2
POINT PROGRAM DESCRIPTION
AND OPERATOR'S GUIDE

Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract No. NAS 5-24350
Task Assignment 717

Prepared by:

A. R. Stottlemyer 17 Dec 81

For Dr. D. Lengyel-Frey Date

H. Newhouse 12/16/81

M. Newhouse Date

Reviewed by:

A R Stottlemyer 17 Dec 81

Dr. A. Stottlemyer Date
Section Manager

Approved by:

Michael J. Bielefeld 17 Dec '81

for M. Silbergeld Date
Department Manager

ABSTRACT

The cosmic x-ray experiment (A2) on board the first High Energy Astronomy Observatory (HEAO-1) Satellite is designed to survey the emission of nonsolar x-rays over the entire sky. The HEAO-A2 data processing system provides computerized analysis and bulk data processing for this experiment at Goddard Space Flight Center (GSFC). The POINT program provides a summary of detector digital status as well as accurate start and end times and coordinates for all HEAO points at sources. This document is a complete description of both the form and operational procedures for this program as it exists on the SACC IBM S/360 computer system.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

SECTION 1 - INTRODUCTION

Program POINT extracts the digital status of the six HEAO-A2 detectors during points at sources for specified time intervals. Inputs to the program are the main production data base (MAX) of the A2 processing system and a point list generated by CSC. Outputs are a status summary on line printer and tape, and a printout of coordinates and times for each point. All printout is archived, thereby providing scientists with information on detector configurations and satellite orientations during points. The output tapes facilitate making multiple copies of the digital status.

SECTION 2 - OVERVIEW

2.1 HEAO-A2 DATA PROCESSING SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules which perform quality control, establish data bases for convenient and efficient analysis, and perform some preliminary analysis of the data. The system is designed to perform both as a "quicklook," almost real-time, processor and as an offline "production" data analysis system. The system design incorporates the ability to perform both of these functions in parallel, and also to process large quantities of data in parallel. Figure 2-1 illustrates the system flow. This entire system is in operation on the SACC IBM S/360-75 and S/360-91 computers at GSFC.

2.1.1 DATA INPUT

Data is received from GSFC's Information Processing Division on magnetic tape in a format defined by the NASA document X-565-77-60, Data Processing Requirements for High-Energy Observatory A (HEAO-A), H. Linder, June 1977. Quicklook and production data have the same data and file format, differing only in the accuracy of the satellite attitude and orbit parameters. Quicklook data is normally produced for one orbit per day, and is available within 8 hours of transmission; production data is produced for all telemetry, and is available within 6 weeks of transmission.

In addition to the experiment data tapes, a command summary tape is produced by Marshall Space Flight Center and delivered to the experimenters. This tape contains only a record of commands sent and acknowledged by the satellite.

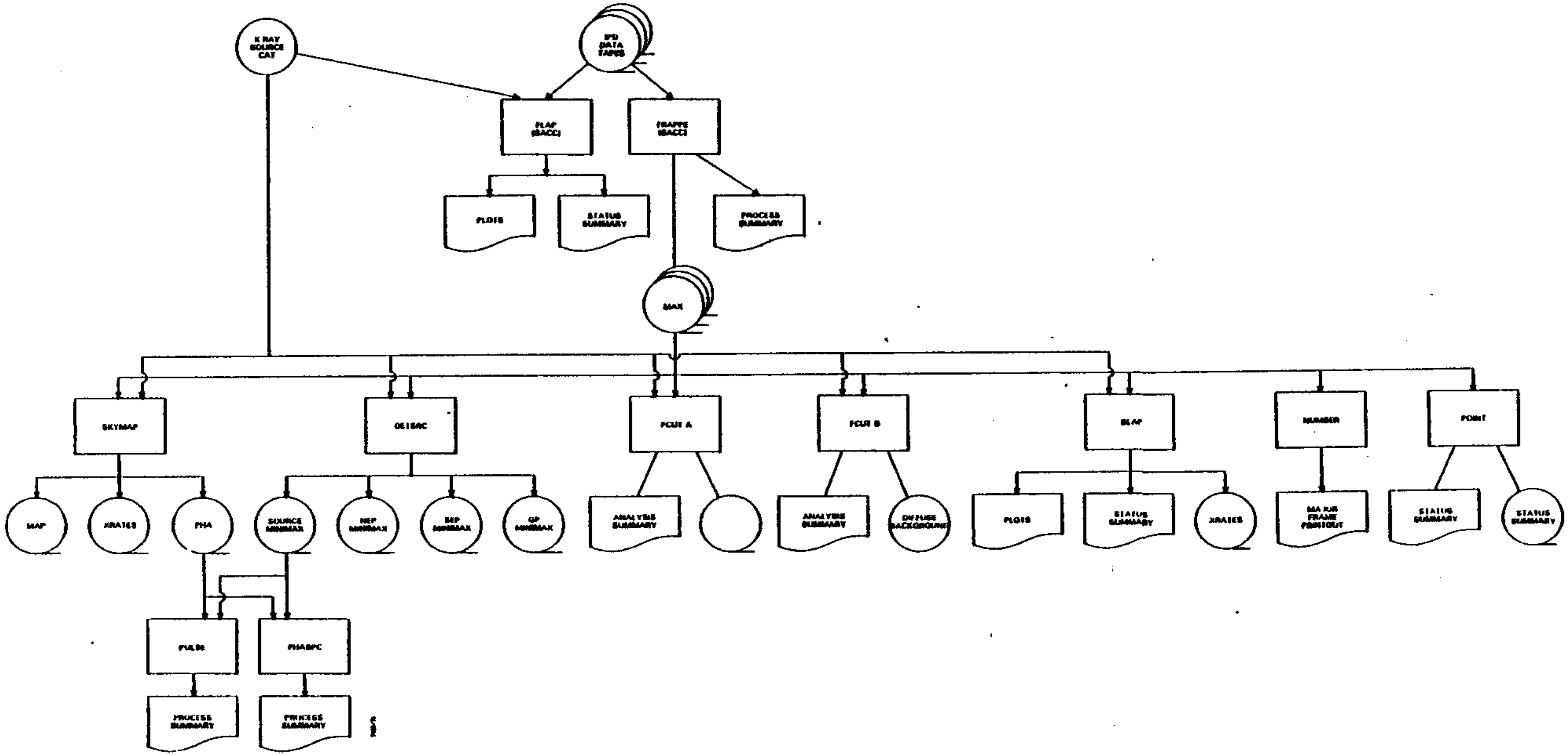


Figure 2-1. HEAO-A2 Data Processing System

An X-ray Source Catalog, which was compiled by the A2 experimenters, incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disk file on the PDP-11/70 computer in the LHEA at GSFC. A condensed version of this catalog, for use by the main data processing system, exists on disk on the SACC computers.

2.1.2 DATA PROCESSING AND ANALYSIS

2.1.2.1 First Look Analysis

The first processing of received data involves performing a series of detailed tests to evaluate data quality and experiment health and status, and displaying some of the raw data in a way which enables some very preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

2.1.2.2 Data Base Production

The next stage of data processing is the production of a restructured data base (MAX), which facilitates the data analysis. This is done by reformatting the data into a FORTRAN-accessible format, reordering the data from telemetry-stream order to accumulation-time order, and setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Reblocking and Production Processing Executive (FRAPPE) program reads an IPD format tape and produces the MAX data base. The file structure of the MAX data base is centered on the changes in the spin axis position which occur approximately every 12 hours. A file mark occurs at each spin axis change, and additional marks designate large (greater than 10 major frames) gaps in the data.

Condensed data bases are created by three programs: SKYMAP, GETSRC, and the two versions of FCUT. SKYMAP is run on all production data and creates up to three specialized data bases. The first, MAP, contains discovery scaler data averaged over time and ordered by the observed location of the sky. The second and third, PHA and XRATES, contain PHA data and discovery scaler data respectively, for major frames with good data. GETSRC extracts major frame records from the MAX tape whenever a selected region of the sky is being observed, and places these records in time order on a separate output tape (MINI-MAX data base). GETSRC is used routinely to create tapes for the data for the North Ecliptic Pole, South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations are created upon request. The FCUT data analysis programs, FCUT-A and FCUT-B, perform routine analysis of production data. FCUT-B calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, and performs a parameterization of the non-X-ray background. FCUT-A searches for new point sources and performs a detailed analysis of the rates of known X-ray sources, forming a data base containing these last results.

The XRATES, MAP, PHA; and FCUT data bases are designed for use with mini-computers, while the MINI-MAX data, due to physical record size, will normally be limited to large computers. Detailed analysis programs, such as PHASPC and PULSE use these specialized data bases as input.

2.1.2.3 Detailed Experiment Analysis

A series of modules use the MAX data base as input. These programs perform preliminary analysis functions.

The first of these modules is the Second Look Analysis Program (SLAP). SLAP generates a complete, detailed experiment status report, and a complete set of detector counting-rate plots. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest. SLAP is used to process all quicklook and production data.

A second module is designed to produce a very detailed output from analysis of limited segments of data. This module, program NUMBER, examines the data on a major frame basis, and generates line printer output for a selected set of data including scaler counting rates, pulse height analysis, and temporal data. Full output from a major frame is approximately six pages long, and includes raw data and output from data analysis.

2.1.2.4 Detailed Data Analysis

Program POINT produces a summary of detector digital status during all HEAO points at sources. Input to the program is the MAX data base and the TRW pointing list, a compilation of point times and coordinates based on TRW data. A printout is generated for each run, giving TRW information and actual point coordinates and times; a separate printout is produced for digital status changes during points. An output tape is written to allow later copies of the digital status reports.

PHASPC accumulates PHA and discovery scaler data for sources and background regions; PULSE is similar to PHASPC but has the added capability of dividing a pulse cycle into a number of segments and accumulating data separately for each segment. These programs, which use either the PHA or GETSRC data base as input, are run for selected time intervals and sources.

2.2 PROGRAM OVERVIEW

Program POINT outputs all digital status words plus time (day and seconds). The status words are ROM/RAM number, high voltage power on/off (HV POWER), high voltage step mode (HV STEP), PHA LSB/MSB Readout time (PHA MSB), PHA channel limit and layer combination (PHA LIM), PHA window definition for layer 1 (PHA W1), PHA window definition for layer 2 (PHA W2), Discovery Scaler 5,6 definition (DS 5,6), Discovery Scaler 7,8 definition (DS 7,8), Discovery Scaler MSB readout (DS MSB), and DPU Δt computer mode (DELTA T). A discussion of the definitions of the flags can be found in the "HEAO-A2 Cosmic X-Ray Experiment Technical Manual" by R. Rothschild, May 1, 1977. A separate output also includes the predicted start and end times and coordinate of each point and the actual values based on axis stability calculations.

For each major frame (MF) which has a change in one or more of the words, the MF time and the new word or words are output. Each status record is written to disk separated by detector for later transferral to tape at the end of the current point. The point duration is defined on the HEAO-A2 Point List, which contains point start and end time, source name, and position. Data for the Point List was gathered by CSC from several sources, mainly TRW attitude data sheets, but also Experimenter of the Day (XOD) logs and program FLAP runs. Since initial information for some points was inaccurate or missing, POINT was occasionally run in an iterative manner, with data from a run used to update the Point List and the new Point List data input to the program to obtain a better analysis of a point. The Point List is described in Appendix A.

Two sets of printer output are generated by each run of Program POINT. The first printout on unit 6, shows Point List source name, times and coordinates for a point, and "actual" coordinates and start time from MAX tape data for the time interval. File and record information for the output tape are also given. The second printout gives the digital status; this information is also written on the output tape.

2.3 PROGRAM DESIGN

The overall structure of Program POINT is shown in the hierarchy diagram (Figure 2.2) and the subroutine cross reference chart (Figure 2.3). Main routine POINT is responsible for reading in NAMELIST input parameters, Point List records, and MAX tape data. Two NAMELISTs are used for input; the first, INTAP, pertains to input and output tape volume names and files. The second, RUNTIM, specifies start and end time for the run. POINT reads each record of the Point List until the first record after the chosen start day is found. If the point is a "ping-pong" point (PP flag on Point list record), the next record, which is the second target of the ping pong point, is also read in.

POINT then reads a MAX record, i.e., Major Frame, and stores it in COMMON block /CURREC/. Only Major Frames free from block encoder or bit errors and fill data (HERRF=0) are accepted for analysis. The time of the MF is compared to the predicted start and end times for the first chosen record from the Point List. MFs which occur before a point has begun are checked to determine if the spacecraft Y axis is changing by less than 1° during the frame; if so, this indicates a possible point is occurring and therefore an apparent discrepancy with the Point List. A message is written to flag the situation for further study. If the MF time is greater than the end time of the point, the next Point List record is read for analysis.

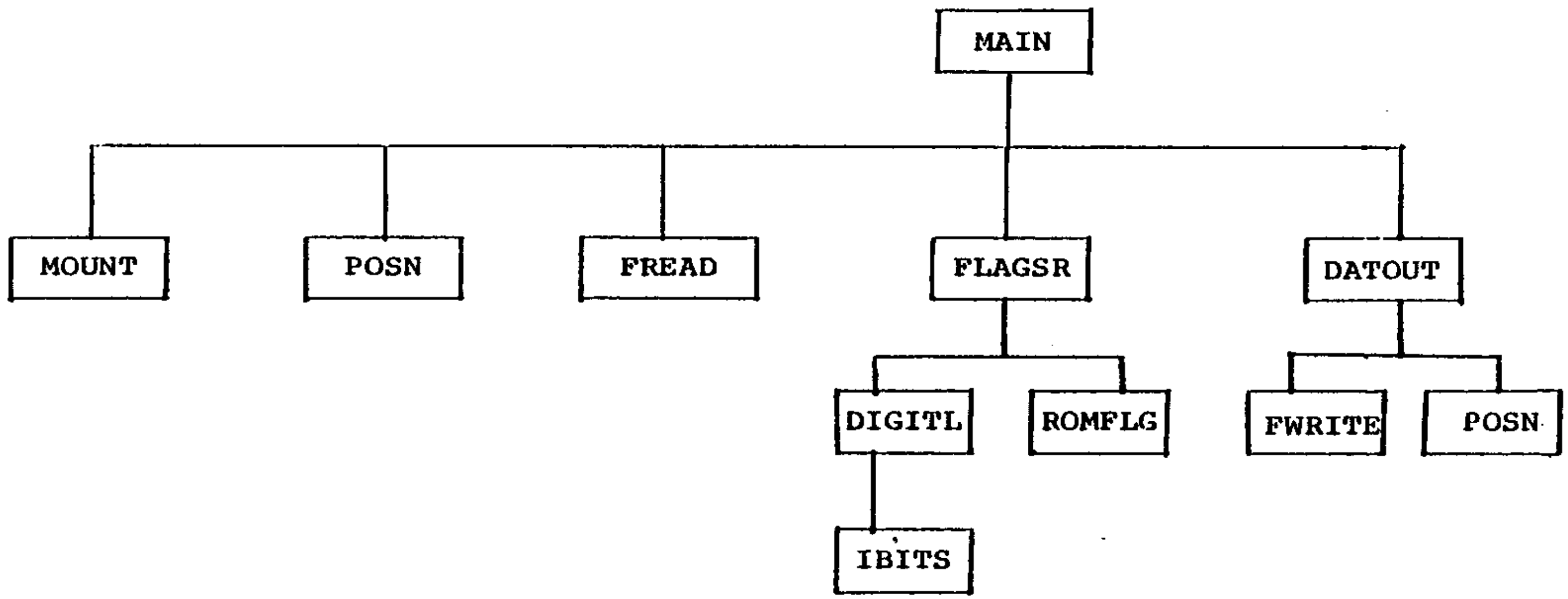


Figure 2-2. Subroutine Hierarchy Diagram

SUBROUTINE FUNCTIONAL DEFINITIONS

DATOUT:	Moves data on disk to printer and final tape copy.
DIGITL:	Extracts 10 digital status flags.
FLAGSR:	Controls status flag calculations and storage.
FREAD:	FTIO routine to read an unformatted logical record.
FWRITE:	FTIO routine to write an unformatted logical record.
IBITS:	SACC bit-testing routine.
MAIN:	Main driver for POINT program, performing data input and axes stability calculations and controlling flag calçulations and output.
MOUNT:	FTIO routine to mount and position magnetic tape volume.
POSN:	FTIO routine to position a unit to a new file.
ROMFLG:	Determines ROM/RAM format.

CALLING ROUTINE \ CALLED ROUTINES	DATOUT	DIGITL	FLAGSR	FREAD	FWRITE	IBITS	MOUNT	POSN	ROMFLG
DATOUT					●			●	
DIGITL						●			
FLAGSR		●							●
MAIN	●		●	●			●		

Figure 2-3. Subroutine Cross-Reference

SUBROUTINE \ COMMON BLOCK	CONST	CURREC	FLAG	FLAG1	OUT	TAPDAT
DATOUT				●	●	●
DIGITL		●	●			
FLAGSR	●	●	●	●		
MAIN	●	●	●	●	●	●
ROMFLG		●	●			

Figure 2-4. Common Block Cross-Reference

MFs which occur during a point as determined from the Point List are analyzed to ascertain whether the satellite axes are stable, i.e., change by less than 1° during the MF. If the axes change by more than 1°, no status determinations are made and a message is written as a warning that the point may be ending. No message is printed during ping-pong mode since large attitude changes are common during such points.

At the start of a point, the coordinates (right ascession (α) and declination (δ)) of the first MF are translated into hours, minutes, and degrees, and a source name based on the coordinate is written out to allow a ready comparison of Point List source data and actual point data. The completed source name and MF coordinates and time are written to disk in the point header record.

For each detector, POINT calls FLAGSR to extract the digital status in the MF. For even MFs, the status for detectors 1 to 3 is found; for odd MFs, the status for detectors 4 to 6 is obtained. FLAGSR first calls ROMFLG to find the ROM/RAM format for the detector; this is stored in HMFORM and HRAM in the MAX record. If fill data is indicated in HMFORM, the record is not analyzed. FLAGSR then calls DIGITL, which extracts digital status records from the QDSTAT and QCSTAT arrays. Array QDSTAT contains digital status for three detectors, whereas QCSTAT has the DPU status for all six detectors.

The digital status in QDSTAT is stored as QDSTAT (N + 13n) where n=0, 1, or 2 for detectors 1, 2, or 3 in even MFs, or detectors 4, 5, or 6 in odd MFs; N is the location of the flags of interest in this analysis. They are as follows:

Flag	N	Bits
HV ON/OFF	26	4
HV STEP	35	7-4
PHA LIM	32	3-2
PHA W1	33	7-4
PHA W2	29	5-4
DS 5,6	31	7-4
DS 7,8	31	3-0

where bit i implies bit 2**i.

QCSTAT(I) contains the PHA MSB (bits 2-1), DS MSB (bit 3) and the ΔT computer (bits 7-4), where I=1 to 6 implies detectors 1 to 6.

FLAGSR stores flags for each detector in arrays which are updated whenever a status change occurs. If the low voltage of the low energy detector (LED) is off, no status is output for LED1 or LED2. For the first MF of a point, digital status flag titles are written to disk for each detector, followed by the time and the digital status flags for the MF. Thereafter, POINT writes a flag to disk only when the flag changes; the time of the change is also output. Status for each detector is written to a separate disk unit, so that the status printed and written to tape is separated by detector.

At the end of a point, DATOUT is called to output the disk unit information onto the output tape and to line printer. DATOUT mounts the output tape and positions to the start file with data for the header and each detector in a separate file. Before outputting to tape, an end-of-file is written on each disk unit and the unit rewound. The data is then copied from disk to tape for those units having data, and each unit is rewound for use in the analysis of the next point.

All tape accesses are performed via SACC FORTRAN Input/ Output (FTIO) utility routines FREAD, FWRITE, POSN, MOUNT, and REWIND. The COMMON block usage is outlined by the COMMON Block Cross Reference Chart (Figure 2.4). COMMON block CURREC is used to access the input MAX data; TAPDAT contains the output data to be written to tape.

Two utility programs are used to dump the POINT tape source and digital status information. Program PNTTAP reads and writes each POINT record as it appears on tape for selected files. Program PNTHED dumps header records containing only source name, coordinates, and point start times.

SECTION 3 - OPERATOR'S GUIDE

3.1 SYSTEM REQUIREMENTS

Program POINT is written in FORTRAN and has been implemented on the SACC IBM S/360-91 and S/360-75 computers. It is run from load module POINT.LOAD member POINT stored on tape XR0125, file 18. POINT requires approximately 250 K bytes of core. For a run processing 2 days of data, POINT requires approximately 2 minutes CPU and 4 minutes I/O time. The source is contained in the data set POINT.FORT in file 17 on XR0125.

The JCL necessary to run POINT is stored in HEAO1.JCL(POINT) on XR0125, file 34 or POINT.FORT(RUNPNT). For each run, appropriate changes must be made to the RUNTIM and INTAP NAMELIST values.

3.2 INPUT DATA

Input data include the Point List, the MAX data base, and two NAMELISTS. The Point List is described in Appendix A. The MAX data base is described in the <u>High Energy Astronomy Observatory Satellite (HEAO-A2) FRAPPE Program Description and Operator's Guide</u>. The NAMELIST variables are described in this section.

Two NAMELIST inputs are used for setting run parameters; these are NAMELISTs, INTAP, and RUNTIM. The variables in INTAP are as follows:

Variable	Type	Definition
NTAPIN	I*4	Number of input MAX tapes
DTAPIN(4)	R*8	MAX tape numbers in quotes
IFILS(4)	I*4	Start file on input tape; default is file #1
DTAPEO	R*8	Output tape name in quotes
NFILE	I*4	Start file for output tape

The variables in RUNTIM are as follows:

Variable	Type	Definition
ISTDAY	I*4	Start day for analysis
ISTSEC	I*4	Start time in seconds
IENDAY	I*4	End day
IENDSC	I*4	End time in seconds

If only one point is to be processed, the variables in RUNTIM should be set to the times found on the Point List for the point. If, however, a series of points is to be processed, the desired start and end days are set with ISTSEC=0 and IENDSC=99999.

3.3 OUTPUT DATA

Output data consists of printout and magnetic tapes. Both are described in this section.

3.3.1 PRINTER OUTPUT

Printed output from a normal run consists of the following: source name from the Point List; coordinates and times from the Point List, referred to as TRW coordinates and times; computed source name based on coordinate of first MF of point; actual coordinates and times, i.e., time and coordinates of first MF of point; for non-pint-pong points, and the number of files and records and file numbers on output tape for the point. If the detector axes change substantially during a MF before the end time from the Point List, a message "Apparent End of Point" is printed along with MF time, coordinates and changes in α and δ during the MF.

If the start time of a point, as found in a run, is more than 30 minutes after the Point List time for the point, a message is written. In addition, if Point List coordinates and MF coordinates at the start of a point differ by more than 4°, a message is written.

If it is found that detector axes are stable, changing by less than 1° during a non-point interval on the Point List, a message "Apparent Point Not on TRW List" is written, along with times and coordinates; the message is written only every 22 MFs, or at intervals of about 15 minutes.

3.3.2 MAGNETIC TAPE OUTPUT

The magnetic tape output contains the digital status information in separate files for each detector and for each point. There are three POINT tapes, each having the following attributes:

Record Format:	fixed block
Record Length:	133 bytes
Block Size:	6650 bytes
Label:	NL
Density:	4
Volumes:	XR0112, XR0113, XR0114

Currently, there are two separate file structures on the POINT tapes representing changing output specifications. For the first 77 files on the first output tape, three records of header information are repeated for each detector. All subsequent data has been separated into a three-record header file followed by up to six files containing the digital status information for each available detector.

All files can be accessed using QDAT(133) assigned as a LOGICAL*1 variable. Each record is in EBCDIC character formatted form. The three header records are as follows:

```
Record 1 - 38X, 'SOURCE NAME(S): XX'7A1
Record 2 - 13X, 'ACTUAL POINT COORDINATES:
              RA =', F8.2, 'DEC = ', F8.2
Record 3 - 13X, 'ACTUAL START TIME : DAY =', I5,
              ' SEC = ', I7
```

Each digital status record contains the following code:

```
MFDAY, MSEC, DROMR, DREC(I),I=1,10
FORMAT (4X,I4,I10,11(2X,A8))
```

where

MFDAY	is the major frame day
MSEC	is the major frame time in milliseconds
DROMR	contains the ROM/RAM format
DREC	for the major frame contains the following digital status information: HV, HVSTEP, PHA MSB, PHA LIM, PHAW1, PHAW2, DS56, DS78, DS MSB, DELTA T

APPENDIX - POINT LIST

This appendix contains information concerning the Point List. The HEAO-A2 Point List is used as input on unit 2. This is stored in ZBDAL.LIB.POINT(PNTLST) and HEAO1.LIST (POINT). Variables in the Point List are as follows:

Variable	Definition
SRC(4)	Source name
RA	Source right ascension
DEC	Source declination
IDS	Start day of point
ISS	Start time (seconds)
IDE	End day of point
ISE	End time (seconds)
PFLG	Ping-pong flag PP=ping pong point blank=single point

A Point List record is read with the following format:

(4A4,7X,F6.2,1X,F6.2,1X,I3,3X,I5,1X,I3,3X,I5,T69,A2)

Point List data was derived from several sources, including TRW Operations Control Center data, the HEAO-A point book (containing data on planned points), Program FLAP runs, and, finally, wherever the above was inadequate or inaccurate, POINT runs or Program MAXATT (in POINT.FORT(MXATT) runs).

CSC

COMPUTER SCIENCES CORPORATION

Major Offices and Facilities Throughout the World

D101256

266-269
9/23/77-9/26/77

266

RECORD 1053 OF FILE 1
LENGTH = 15168 BYTES

0000010A 02FE47A3 00010001 00010000 003F003F 0FFC0006 00030000 00000000 AAAAAAAA AAAAAAAA
AAAAAAAA AAAAAAAA 0000000B B147D761 0019B1FF B1B1B1B1 19003838 70196129 024A0000 7DD810D5
177101EB BAB3F600 00500000 0000CD00 00008800 00005000 000000CC 000000E8 00000050 00000000
CD000000 88000000 A9710004 9D000000 A5710049 96710048 A171009C 93700038 8A917869 D60600A6
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101 01010101
01010101 01010101 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00B02B00 00B02B01 00B02B02 00B02B03
00B02B04 00B02B05 00B02B06 00B02B07 00B02B08 00B02B09 00B02B0A 00B02B0B 00B02B0C 00B02B0D
00B02B0E 00B02B0F 00B02B10 00B02B11 00B02B12 00B02B13 00B02B14 00B02B15 00B02B16 00B02B17
00B02B18 00B02B19 00B02B1A 00B02B1B 00B02B1C 00B02B1D 00B02B1E 00B02B1F 00B02B20 00B02B21
00B02B22 00B02B23 00B02B24 00B02B25 00B02B26 00B02B27 00B02B28 00B02B29 00B02B2A 00B02B2B
00B02B2C 00B02B2D 00B02B2E 00B02B2F 00B02B30 00B02B31 00B02B32 00B02B33 00B02B34 00B02B35
00B02B36 00B02B37 00B02B38 00B02B39 00B02B3A 00B02B3B 00B02B3C 00B02B3D 00B02B3E 00B02B3F
00B02B40 00B02B41 00B02B42 00B02B43 00B02B44 00B02B45 00B02B46 00B02B47 00B02B48 00B02B49
00B02B4A 00B02B4B 00B02B4C 00B02B4D 00B02B4E 00B02B4F 00B02B50 00B02B51 00B02B52 00B02B53
00B02B54 00B02B55 00B02B56 00B02B57 00B02B58 00B02B59 00B02B5A 00B02B5B 00B02B5C 00B02B5D
00B02B5E 00B02B5F 00B02B60 00B02B61 00B02B62 00B02B63 00B02B64 00B02B65 00B02B66 00B02B67
00B02B68 00B02B69 00B02B6A 00B02B6B 00B02B6C 00B02B6D 00B02B6E 00B02B6F 00B02B70 00B02B71
00B02B72 00B02B73 00B02B74 00B02B75 00B02B76 00B02B77 00B02B78 00B02B79 00B02B7A 00B02B7B
00B02B7C 00B02B7D 00B02B7E 00B02B7F 41323BE3 41323BD6 41323BC8 41323BBC 41323BAE 41323BA2
41323B93 41323B85 41323B76 41323B69 41323B5C 41323B4D 41323B3F 41323B31 41323B23 41323B14
41323B06 41323AF7 41323AE9 41323AD9 41323ACB 41323ABB 41323AAD 41323A9F 41323A8F 41323A80
41323A72 41323A62 41323A53 41323A44 41323A34 41323A23 BF1378AB BF1373DE BF136E57 BF136CBE
BF1366B3 BF136457 BF135F57 BF135A9A BF135608 BF1351FC BF134E30 BF134934 BF1346AC BF134137
BF133C96 BF1337D2 BF1334F9 BF132F7B BF132C29 BF132605 BF132176 BF131C47 BF131853 BF13142C
BF130D80 BF1309A4 BF1304CF BF12FECE BF12FB06 BF12F562 BF12EF50 BF12E8A7 414B641B 414B63F8
414B63D3 414B63B1 414B638D 414B636B 414B6346 414B6322 414B62FD 414B62DA 414B62B7 414B6293
414B6270 414B624C 414B6228 414B6204 414B61E1 414B61BD 414B619A 414B6175 414B6152 414B612D
414B610A 414B60E7 414B60C2 414B609E 414B607B 414B6057 414B6034 414B6010 414B5FEB 414B5FC6
C04F5965 C04E5E54 C04D631C C04C67E4 C04B6CAC C04A712D C04975DE C0487A67 C0477EF1 C046838A
C045880B C0448C85 C04390F7 C0429571 C04199D3 C0409E0E C03FA232 C03EA675 C03DAAC8 C03CAEE4
C03BB32F C03AB714 C039BB3F C038BF54 C037C358 C036C73D C035CB1B C034CF00 C033D2F5 C032D6D2
C031DA90 C030DE3C 414D8E4A 414D8E2F 414D8E11 414D8DF8 414D8DDB 414D8DC2 414D8DA3 414D8D86
414D8D67 414D8D4B 414D8D30 414D8D11 414D8CF6 414D8CD7 414D8CB9 414D8C9A 414D8C7F 414D8C5F
414D8C43 414D8C21 414D8C03 414D8BE2 414D8BC6 414D8BA9 414D8B86 414D8B67 414D8B49 414D8B27
414D8B09 414D8AE9 414D8AC7 414D8AA2 4110B92E 4110B92E 4110B92E 4110B92B 4110B92B 4110B928
4110B928 4110B927 4110B925 4110B924 4110B922 4110B921 4110B91F 4110B91E 4110B91D 4110B91C
4110B919 4110B919 4110B916 4110B916 4110B915 4110B914 4110B912 4110B911 4110B911 4110B90E
4110B90E 4110B90D 4110B90B 4110B90A 4110B90A 4110B90A 4033FB56 4034D474 4035ADB1 4036870B
40376061 40383A09 40391380 4039ED2C 403AC6D9 403BA08E 403C7A6B 403D544A 403E2E4F 403F0849
403FE26C 4040BCB9 40419736 40427197 40434C09 404426A6 40450138 4045DC28 4046B6FC 404791F4
40486CF9 40494836 404A2393 404AFEF1 404BDA5F 404CB5EE 404D91A9 404E6D7F 3FA16BC0 3FA95219
3FB13A7E 3FB9204A 3FC10724 3FC8EE50 3FD0D591 3FD8BCA7 3FE0A42D 3FE88988 3FF06E2C 3FF85435
4010037F 401081C8 40110005 40117E55 4011FC8F 40127AC6 4012F8CF 4013770A 4013F507 4014733C
4014F122 40156F09 4015ED09 40166AF8 4016E8CE 401766A4 4017E450 40186203 4018DFBB 40195D7C

283

RECORD 2 OF FILE 9
LENGTH = 15168 BYTES

0000010D	0300B3A8	00010001	00000000	00060006	0FC00000	003F0003	00000000	AAAAAAAA	AAAAAAAA
AAAAAAAA	AAAAAAAA	0000000B	BABDC864	0015B1B1	B1B1B1B1	15006E6E	6E6E6E6E	6E6E0000	7DD810D5
177101D4	32100300	00400000	0000CD00	00008800	00004000	000000CC	000000E8	00000040	00000000
CD000000	88000000	A8960004	A1910001	AA970003	9A940004	A3960003	958E0004	04557767	9E39009E
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101	01010101
01010101	01010101	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00BC8900	00BC8901	00BC8902	00BC8903
00BC8904	00BC8905	00BC8906	00BC8907	00BC8908	00BC8909	00BC890A	00BC890B	00BC890C	00BC890D
00BC890E	00BC890F	00BC8910	00BC8911	00BC8912	00BC8913	00BC8914	00BC8915	00BC8916	00BC8917
00BC8918	00BC8919	00BC891A	00BC891B	00BC891C	00BC891D	00BC891E	00BC891F	00BC8920	00BC8921
00BC8922	00BC8923	00BC8924	00BC8925	00BC8926	00BC8927	00BC8928	00BC8929	00BC892A	00BC892B
00BC892C	00BC892D	00BC892E	00BC892F	00BC8930	00BC8931	00BC8932	00BC8933	00BC8934	00BC8935
00BC8936	00BC8937	00BC8938	00BC8939	00BC893A	00BC893B	00BC893C	00BC893D	00BC893E	00BC893F
00BC8940	00BC8941	00BC8942	00BC8943	00BC8944	00BC8945	00BC8946	00BC8947	00BC8948	00BC8949
00BC894A	00BC894B	00BC894C	00BC894D	00BC894E	00BC894F	00BC8950	00BC8951	00BC8952	00BC8953
00BC8954	00BC8955	00BC8956	00BC8957	00BC8958	00BC8959	00BC895A	00BC895B	00BC895C	00BC895D
00BC895E	00BC895F	00BC8960	00BC8961	00BC8962	00BC8963	00BC8964	00BC8965	00BC8966	00BC8967
00BC8968	00BC8969	00BC896A	00BC896B	00BC896C	00BC896D	00BC896E	00BC896F	00BC8970	00BC8971
00BC8972	00BC8973	00BC8974	00BC8975	00BC8976	00BC8977	00BC8978	00BC8979	00BC897A	00BC897B
00BC897C	00BC897D	00BC897E	00BC897F	4133111D	4133111E	41331123	4133112C	41331134	41331142
4133114F	4133115F	41331173	41331188	4133119F	413311B7	413311D2	413311F0	41331211	41331232
41331255	4133127C	413312A4	413312D0	413312FD	4133132A	4133135B	4133138F	413313C3	413313F9
41331432	4133146F	413314AB	413314EC	4133152C	4133156D	BF57BA4A	BF57D10C	BF57E84E	BF57FC86
BF581094	BF582408	BF583653	BF584AB8	BF585C34	BF586C31	BF587B80	BF588C63	BF589B72	BF58A98C
BF58B506	BF58C178	BF58CDAA	BF58D8D4	BF58E24A	BF58EA02	BF58F334	BF58FC4B	BF5901A1	BF5906C5
BF590A19	BF590E92	BF5911B2	BF59123F	BF591382	BF591214	BF59126A	BF592C7D	411C9F98	411C8C24
411C79CD	411C685F	411C57DF	411C4833	411C394B	411C2B2C	411C1DAB	411C10C2	411C0471	411BF8B5
411BED75	411BE2AC	411BD84E	411BCE62	411BC4DB	411BBBB3	411BB2E0	411BAA5F	411BA239	411B9A5D
411B92BC	411B8B65	411B8447	411B7D6F	411B76CF	411B7062	411B6A2D	411B6426	411B5E57	411B5937
41171856	411708F0	4116F989	4116EA1C	4116DAB1	4116CB3F	4116BBCD	4116AC58	41169CE2	41168D68
41167DEF	41166E74	41165EF6	41164F76	41163FF9	41163077	411620F2	4116116D	411601E7	4115F262
4115E2DD	4115D352	4115C3C9	4115B43F	4115A4B6	4115952A	4115859B	4115760F	41156681	411556F3
41154763	41153813	414F4D1A	414F4D2A	414F4D40	414F4D5D	414F4D78	414F4D9E	414F4DC2	414F4DEB
414F4E1B	414F4E4D	414F4E82	414F4EBA	414F4EF7	414F4F39	414F4F7D	414F4FC4	414F500F	414F505F
414F50B2	414F510A	414F5164	414F51C1	414F5221	414F5288	414F52ED	414F5357	414F53C6	414F543C
414F54AE	414F552A	414F55A4	414F5630	4110C030	4110C01A	4110C005	4110BFF5	4110BFE4	4110BFD5
4110BFC8	4110BFB8	4110BFAD	4110BFA4	4110BF9C	4110BF93	4110BF8D	4110BF88	4110BF86	4110BF84
4110BF82	4110BF83	4110BF85	4110BF8B	4110BF8F	4110BF93	4110BF9C	4110BFA6	4110BFB2	4110BFBD
4110BFCB	4110BFDC	4110BFEC	4110C000	4110C012	4110C00B	4124A3E3	4124B4F9	4124C60B	4124D71B
4124E822	4124F92B	41250A2D	41251B2D	41252C29	41253D22	41254E14	41255F03	41256FF0	412580DA
412591BB	4125A29B	4125B37A	4125C454	4125D529	4125E5F8	4125F6C2	4126078E	41261853	41262914
412639CE	41264A87	41265B3D	41266BED	41267C99	41268D40	41269DE5	4126AE46	40797E13	4079461D
40790DC4	4078D4C5	40789B5C	4078616E	40782705	4077EC49	4077B0F7	40777518	407738CF	4076FC2C
4076BEFE	40768157	4076432D	4076049A	4075C592	4075861C	40754625	407505B9	4074C4FF	407483C5
407441F9	4073FFD1	4073BD2A	40737A27	407336AF	4072F2C0	4072AE6D	407269A3	40722483	4071E1B3

HEAO-1

A-2 FCUT TIMED DATABASE

77-075A-02O

This data set consists of 2 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on an IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101448	C-032302	597	09/08/77 - 06/09/78
D-101449	C-032303	455	06/10/78 - 01/09/79

CSC/TM-81/6123

HIGH ENERGY ASTRONOMY OBSERVATORY-A2 SKYMAP PROGRAM DESCRIPTION AND OPERATOR'S GUIDE

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-24350
Task Assignment 608

SEPTEMBER 1981

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-81/6123

HIGH ENERGY ASTRONOMY OBSERVATORY-A2
SKYMAP PROGRAM
DESCRIPTION AND OPERATOR'S GUIDE

Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-24350
Task Assignment 608

Prepared by:

D. Derrick 9/24/81
D. Derrick

M. Newhouse 9/24/81
M. Newhouse

Reviewed by:

A. R. Stottlemyer 9/24/81
Dr. A. Stottlemyer
Section Manager

Approved by:

M. D. Silbergeld 9/25/81
M. Silbergeld
Department Manager

ABSTRACT

The cosmic ray X-ray experiment (A2) onboard the first High Energy Astronomy Observatory (HEAO-1) satellite is designed to survey the emission of non-solar X-rays over the entire sky. The HEAO-A2 data processing system provides computerized analysis and bulk data processing for this GSFC experiment. SKYMAP is one of the programs in the HEAO-A2 data processing system. The main function of the SKYMAP program is to produce up to three specialized data bases: MAP, PHA, and XRATES. The MAP data base contains X-ray counting rates data, accumulated over time, ordered by the observed position of the sky. The XRATES data base is a condensed version of the main data base for this system containing only X-ray rates data, while the Pulse Height Analyzed (PHA) data base is a condensed version containing the X-ray PHA and limited rates data. This document describes the form and operational procedures for the SKYMAP program as it exists on the SACC IBM S/360 computer system.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND TABLES

Figure

Table

SECTION 1 - INTRODUCTION

The first High Energy Astronomy Observatory (HEAO-1) satellite was launched in August 1977, with the mission of surveying the full sky for non-solar X-ray emission over a wide range of X-ray energies. The A2 experiment consists of six detectors which, together, cover a range in X-ray energy from 0.25 KeV to 60 KeV. The experiment is designed to provide systematics-free energy spectrum data for point and extended sources of X-rays. The detectors are mounted so as to observe the sky in a direction perpendicular to the satellite spin axis. With this orientation, each detector scans a 3-degree-wide great circle of the sky each 30 minutes, and, as the spin axis precesses to point at the Sun, observes the full sky within a period of 6 months.

The six detectors consist of two Low Energy Detectors (LEDs), one Medium Energy Detector (MED), and three High Energy Detectors (HEDs). Each detector observes two co-axial fields-of-view separately, one collimated to 3° by 3° full width at half maximum (FWHM) and the other either 3° by 1-1/2° or 3° by 6°. Each field-of-view is observed by a multi-wire gas proportional chamber with separate outputs for each field-of-view in two layers of anodes, and also for exterior layers of anodes which are used to discriminate against charged particles. The following types of data are output from each detector: engineering and analog parameters (analog status), digital experiment parameters (digital status), raw anode counting rates (housekeeping scalers), standard coincidence counting rates (discovery scalers), pulse height analyzed rates (PHA histograms), calibration pulse height analyzed events (calibration data), and data with a variety of counting rate versus time output modes (Delta-t computer).

Program SKYMAP is designed to produce three specialized data bases: MAP, PHA, and XRATES. Using the main data base of the HEAO-A2 system, MAX, as input, SKYMAP selects and accumulates data from each 40.96 seconds (one major frame) of telemetry data. From each acceptable major frame, the SKYMAP program selects Discovery Scaler rates for the MED and HEDs and accumulates the data over approximately 12 hours for output to the MAP data base. The XRATES and PHA data bases overlap in content, differing primarily in that the XRATES data base contains Discovery Scaler data (1.28-second readouts and 5.12-second sums) for all six detectors, whereas the PHA data base contains limited Discovery Scaler sums and PHA data for only the HEDs and MED. Each data record on the PHA and XRATES tapes is a condensed version of the input record from the MAX tape with the addition of certain data flags calculated by the SKYMAP program. The data bases are output on magnetic tapes for use with detailed analysis programs on either the SACC IBM S/360 or the Laboratory for High Energy Astrophysics (LHEA) PDP-11/70 computer systems.

SECTION 2 - OVERVIEW

2.1 HEAO-A2 DATA PROCESSING SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules which perform quality control, establish data bases for convenient and efficient analysis, and perform some preliminary analysis of the data. The system is designed to perform both as a "quicklook," almost real-time, processor and as an offline "production" data analysis system. The system design incorporates the ability to perform both of these functions in parallel, and also to process large quantities of data in parallel. Figure 2-1 illustrates the system flow. This entire system is in operation on the SACC IBM S/360-75 and S/360-91 computers at GSFC.

2.1.1 DATA INPUT

Data is received from GSFC's Information Processing Division on magnetic tape in a format defined by the NASA document X-565-77-60, Data Processing Requirements for High-Energy Observatory A (HEAO-A), H. Linder, June 1977. Quicklook and production data have the same data and file format, differing only in the accuracy of the satellite attitude and orbit parameters. Quicklook data is normally produced for one orbit per day, and is available within 8 hours of transmission; production data is produced for all telemetry, and is available within 6 weeks of transmission.

In addition to the experiment data tapes, a command summary tape is produced by Marshall Space Flight Center and delivered to the experimenters. This tape contains only a record of commands sent and acknowledged by the satellite.

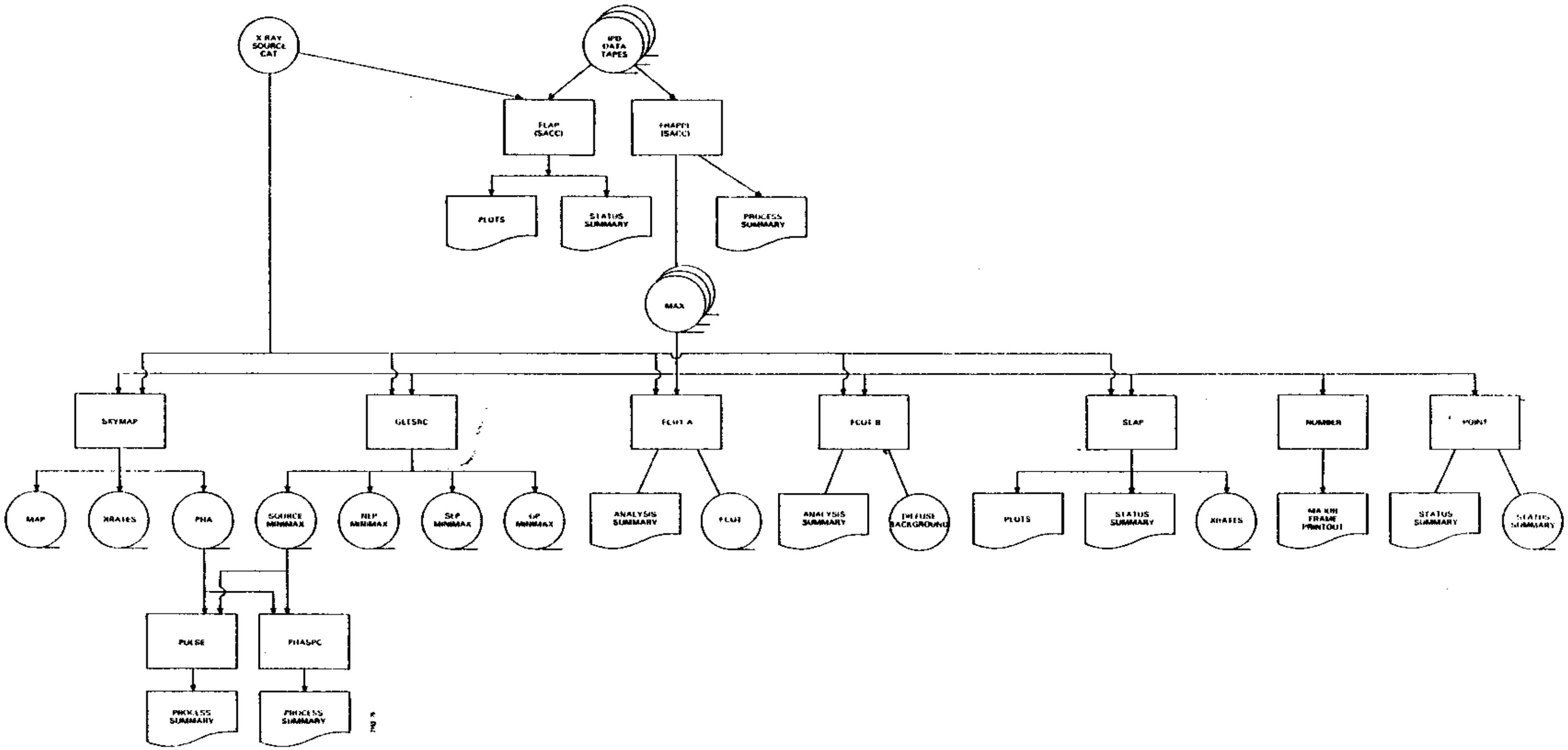


Figure 2-1. HEAO-A2 ta Processing System

An X-ray Source Catalog, which was compiled by the A2 experimenters, incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disk file on the PDP-11/70 computer in the LHEA at GSFC. A condensed version of this catalog, for use by the main data processing system, exists on disk on the SACC computers.

2.1.2 DATA PROCESSING AND ANALYSIS

2.1.2.1 First Look Analysis

The first processing of received data involves performing a series of detailed tests to evaluate data quality and experiment health and status, and displaying some of the raw data in a way which enables some very preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

2.1.2.2 Data Base Production

The next stage of data processing is the production of a restructured data base (MAX), which facilitates the data analysis. This is done by reformatting the data into a FORTRAN-accessible format, reordering the data from telemetry-stream order to accumulation-time order, and setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Reblocking and Production Processing Executive (FRAPPE) program reads an IPD format tape and produces the MAX data base. The file structure of the MAX data base is centered on the changes in the spin axis position which occur approximately every 12 hours. A file mark occurs at each spin axis change, and additional marks designate large (greater than 10 major frames) gaps in the data.

Condensed data bases are created by three programs: SKYMAP, GETCRC, and the two versions of FCUT. SKYMAP is run on all production data and creates up to three specialized data bases. The first, MAP, contains discovery scaler data averaged over time and ordered by the observed location of the sky. The second and third, PHA and XRATES, contain PHA data and discovery scaler data respectively, for major frames with good data. GETSRC extracts major frame records from the MAX tape whenever a selected region of the sky is being observed, and places these records in time order on a separate output tape (MINI-MAX data base). GETSRC is used routinely to create tapes for the data for the North Ecliptic Pole, South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations are created upon request. The FCUT data analysis programs, FCUT-A and FCUT-B, perform routine analysis of production data. FCUT-B calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, and performs a parameterization of the non-X-ray background. FCUT-A searches for new point sources and performs a detailed analysis of the rates of known X-ray sources, forming a data base containing these last results.

The XRATES, MAP, PHA, and FCUT data bases are designed for use with mini-computers, while the MINI-MAX data, due to physical record size, will normally be limited to large computers. Detailed analysis programs, such as PHASPC and PULSE use these specialized data bases as input.

2.1.2.3 Detailed Experiment Analysis

A series of modules use the MAX data base as input. These programs perform preliminary analysis functions and produce several condensed data bases.

The first of these modules is the Second Look Analysis Program (SLAP). SLAP generates a complete, detailed experiment status report, and a complete set of detector counting-rate plots. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest. SLAP is used to process all quicklook and production data.

A second module is designed to produce a very detailed output from analysis of limited segments of data. This module, program NUMBER, examines the data on a major frame basis, and generates line printer output for a selected set of data including scaler counting rates, pulse height analysis, and temporal data. Full output from a major frame is approximately six pages long, and includes raw data and output from data analysis.

2.1.2.4 Detailed Data Analysis

Program POINT produces a summary of detector digital status during all HEAO points at sources. Input to the program is the MAX data base and the TRW pointing list, a compilation of point times and coordinates based on TRW data/ A printout is generated for each run, giving TRW information and actual point coordinates and times; a separate printout is produced for digital status changes during points. An output tape is written to allow later copies of the digital status reports.

PHASPC accumulates PHA and discovery scaler data for sources and background regions; PULSE is similar to PHASPC but has the added capability of dividing a pulse cycle into a number of segments and accumulating data separately for each segment. These programs, which use either the PHA or GETSRC data base as input, are run for selected time intervals and sources.

2.2 SKYMAP PROGRAM OVERVIEW

2.2.1 DATA BASE DESCRIPTIONS

Program SKYMAP generates the MAP, PHA, and XRATES data bases for the HEAO-A2 Data Processing System. Each of the data bases contains a specialized subsection of the HEAO-A2 data.

2.2.1.1 MAP Data Base

The MAP data base consists of a detailed map of both the entire X-ray sky and the X-ray background alone. Only X-ray counting rates (discovery scaler) data in scan mode (i.e., not directed at a specific source) is used. Each 360° scan of the sky is broken into 1440 scan angle bins and the data is accumulated for a period of approximately 12 hours. This maps the sky into bins of approximately 0.5° ecliptic longitude by 0.25° ecliptic latitude bins, with each sky location recorded in the data base approximately once every 180 days. The maps of the entire sky contains all rates data which tests as "Clean", with a McIllwain-L value less than 1.2. The X-ray background map is more restricted. Not only must the data have been accumulated into the all-sky map, but it must also test as "Superclean" and contain no sources in the field-of-view of the detector. (Refer to Appendix A for details of the Clean and Superclean restrictions.)

2.2.1.2 PHA Data Base

The PHA data base separates out spectral data obtained from the PHA aboard the experiment. Each PHA record is a condensed version of a MAX tape record. It contains the PHA data, selected discovery scaler data, data flags from the MAX tape, in addition to flags for Clean and Superclean data, source in field-of-view, pointing mode, electron contamination, digital status, earth occultation, and the position of the moon, calculated by SKYMAP.

2.2.1.3 XRATES Data Base

The XRATES data base is similar. It contains the same data flags, but the PHA data is replaced by a complete set of rates data taken from the input MAX tape.

2.2.2 PROCESSING FLOW

Within each processing run, the user selects the time interval to be processed, specifies which of the three possible tapes are to be produced, and decides whether all data or only clean data, if any, is to be written to the output PHA and XRATES tapes. The user can also specify spin axis positions for each MAX file to be processed, thereby overriding the computed spin axis position based on the position of the Sun at the beginning of the file. This option should be used during time intervals for which the spin axis is known to differ from the position of the Sun by a large angle.

As a first step in processing each segment of data, SKYMAP calculates the satellite spin axis (unless a spin axis override option has been entered) from the major frame time and solar ephemeris. Times from any major frame not containing data gaps or missing attitude data, regardless of memory format, may be used to determine the spin axis position. A list of X-ray sources within 4° of the detector scan plane is then selected from the X-ray source catalog. To limit execution time, only this subcatalog will be referenced in later calculations to determine if a source is within the field-of-view of a given detector. Since the subcatalog is updated only once for every MAX file, the source-in-field-of-view flag will be accurate only if the satellite spin axis is stable to within ± 0.5° over a 12-hour period.

Processing continues from this point only for major frames in ROM1, ROM2, or RAM 1-10 memory formats. Each of the data flags to be output is calculated for each such major frame. To facilitate calculation of the data flags involved with experiment stability, two major frames of data following the major frame being analyzed, and the digital status from the two preceding major frames are maintained in core at all times. Based on the results of the data flag calculations and user-requested options, records may be prepared for and output to the PHA and XRATES tapes and data accumulated for the MAP tape. The accumulated data is written to the MAP tape at the end of each input MAX file and at the end of the time interval being processed.

2.3 SKYMAP PROGRAM DESIGN

The overall structure of program SKYMAP is shown in the Hierarchy Diagram (Figure 2-2) and the Subroutine Cross-Reference Chart (Figure 2-3). The usage of the COMMON data storage areas is indicated in the COMMON Block Usage Chart (Figure 2-4). All the routines are coded in FORTRAN for use with the IBM level-H compiler.

Because of its size, the SKYMAP program has been designed with three primary control sections to keep it flexible. These are the MAIN routine and subroutines PROG1 and PROG2. The MAIN routine directs the handling and overall analysis of the input MAX tape. PROG1 generates some of the tools needed to analyze the contents of a major frame. PROG2 controls the majority of the processes for analyzing data within a major frame, setting the appropriate flags, and writing to the output tapes.

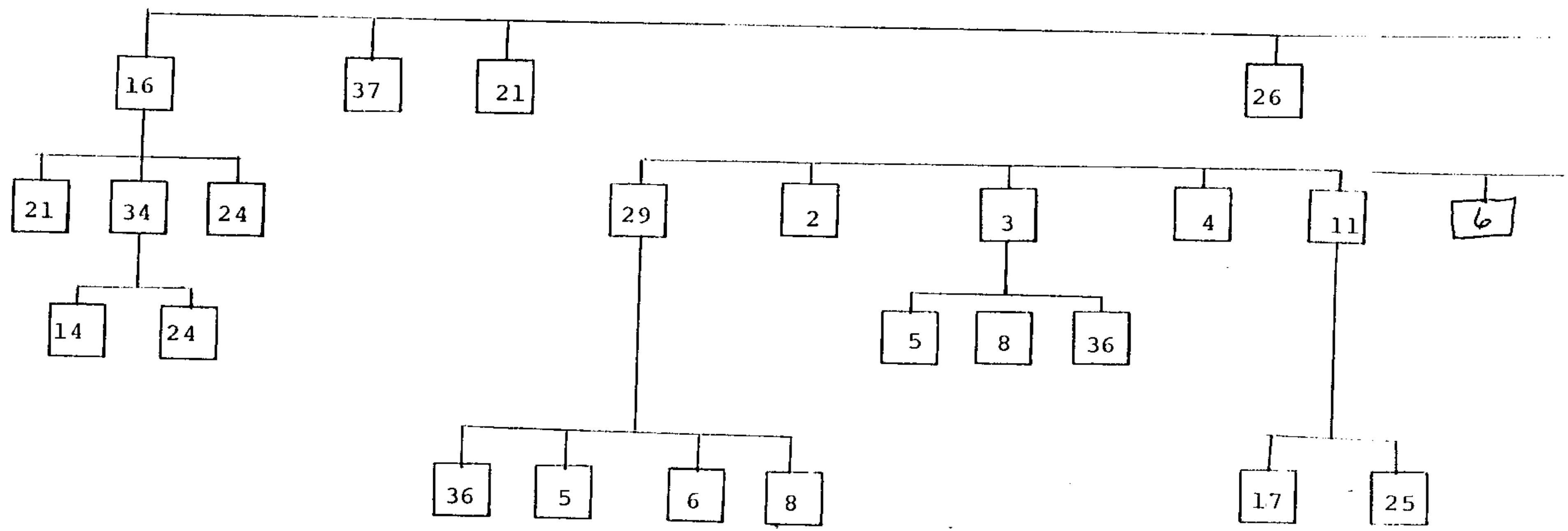


Figure 2-2. SKYMAP Hierarchy Diagram

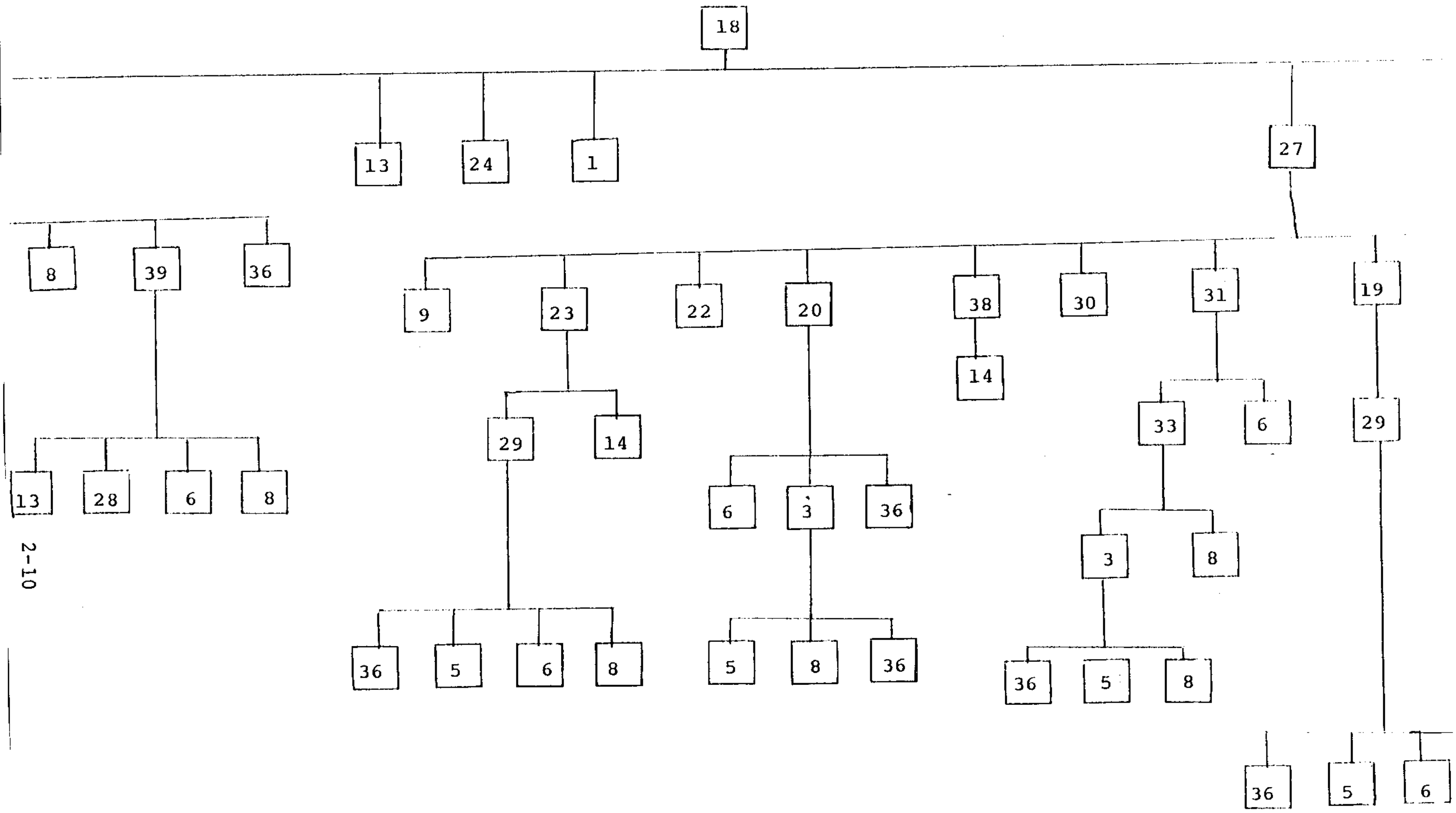


Figure 2-2 (continued). SKYMAP Hierarchy Diagram

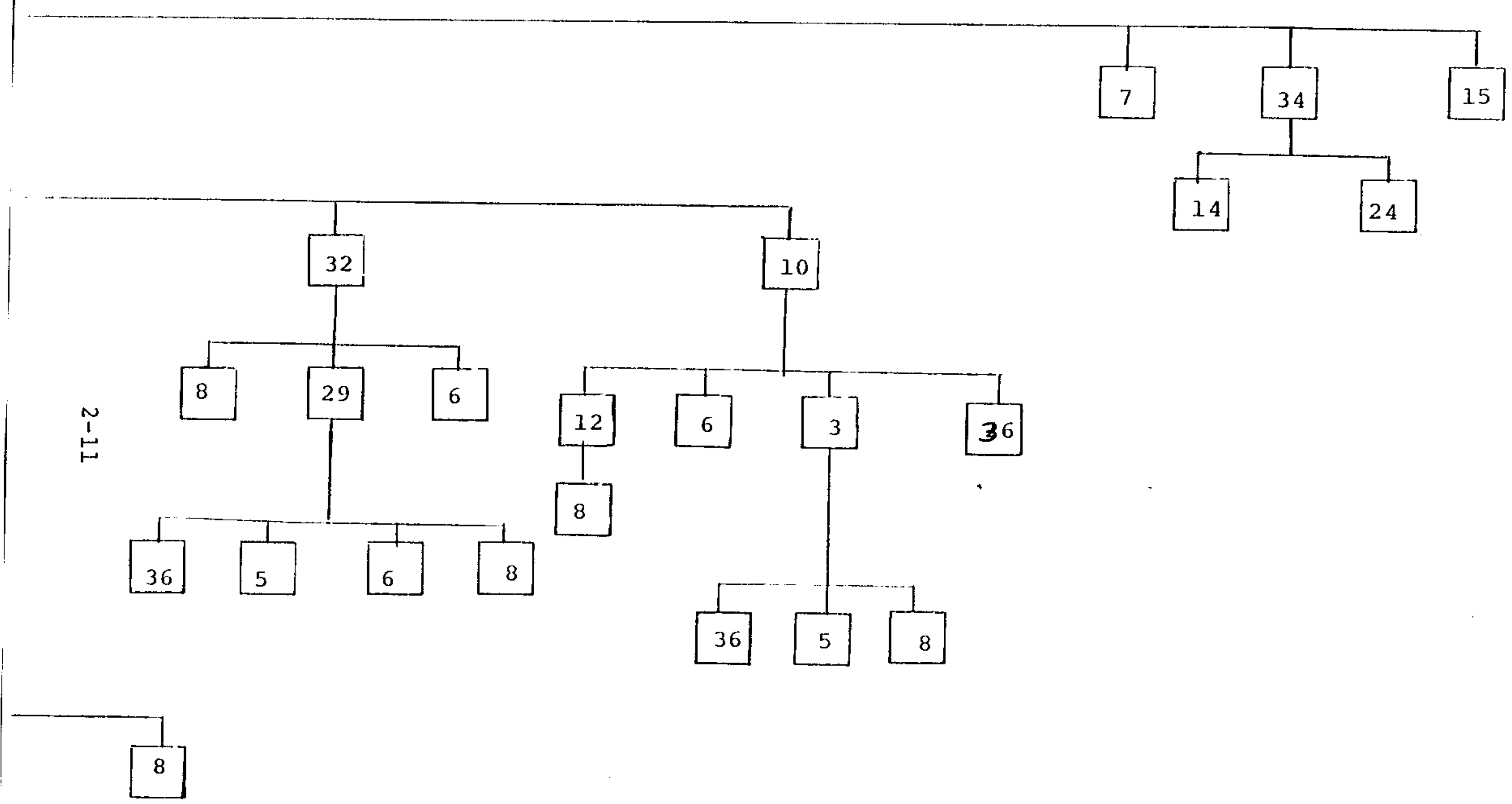


Figure 2-2 (continued). SKYMAP Hierarchy Diagram

HIPO TABLE OF CONTENTS

1.	CLEAN	Determines clean, DPU, and digital status of each detector in a major frame.
2.	CONECL	Calculates ecliptic coordinates from celestial coordinates.
3.	CONVEC	Given two orthogonal vectors defining a coordinate system, CONVEC defines a third input vector with respect to the input coordinate system.
4.	CONVER	Converts celestial coordinates from 1978 epoch to 1950 epoch.
5.	CROSS	Computes the cross product of two vectors.
6.	CVXYZ	Given the ecliptic or celestial coordinates of a vector, CVXYZ expresses the vector in Cartesian (X,Y,Z) coordinates.
7.	DIGIT	Saves the digital status of the experiment and of the appropriate three detectors in each major frame.
8.	DOT	Calculates vector dot product.
9.	ECOUNT	Sets the electron contamination flag for detectors 3-6 in a major frame.
10.	EOCC	Sets the Earth occultation flags for each of the six detectors.
11.	EPHEM	Coordinates the process by which the position of the Sun can be determined from a given day and time.
12.	FOVIEW	Determines if a given source (sky location) is within the field-of-view of a given detector.

13.	FREAD	Reads a logical record; a FORTRAN Input/ Output (FTIO) routine.
14.	FWRITE	Writes a logical record; an FTIO routine.
15.	HEADER	Prints the header record at the beginning of each MAX volume.
16.	INIT	Initializes variables, reads input parameters, and sets the processing selection switches.
17.	JDAY	Standard function to calculate Julian day number.
18.	MAIN	Handles overall control of processing.
19.	MAPTAP	Forms the cumulative discovery scaler sums and exposure matrices.
20.	MFOV	Determines if the Moon is in the field-of-view of any detector.
21.	MOUNT	Mounts a tape volume; an FTIO routine.
22.	NOMINL	Determines if the contents of a major frame are in the defined nominal mode.
23.	PHATAP	Fills in a COMMON block and writes its contents to the output PHA tape for each acceptable record of the input tape.
24.	POSN	Positions a tape to a file; an FTIO routine.
25.	POSSUN	An entry point in subroutine SUNMUN. See number 35.
26.	PROG1	Transfers the current major frame to a COMMON block. Whenever necessary, it also determines the nominal spin position, compiles a source catalog, and calculates data for record type zero of the MAP tape.

27. PROG2 — Secondary driver of the SKYMAP program. Controls the setting of data flags, the writing of records to the PHA and XRATES files, and the accumulation of data for the MAP tape.

28. REWIND — Positions volume to beginning of data set; an FTIO routine.

29. SCANGL — Calculates ecliptic scan angle from celestial coordinates.

30. SCLEAN — Determines the status for each detector in a major frame.

31. SINFOV — Sets the flag which indicates, for each detector, whether a source appears in the detector's small and large field-of-view.

32. SPFLAG — Sets the flag indicating if the spin period is nominal, and whether the spin axis is within 2° of the Sun. This flag is referred to as the "pointing" flag.

33. SRCLOC — For detectors HED1 - HED3 and MED, determines if a given sky location appears in the large field-of-view and small field-of-view of each detector.

34. SUMOUT — Prints end-of-file messages, closes the PHA and XRATES tapes, writes records to and closes the MAP tape.

35. SUNMUN — Standard routine for calculating solar ephemeris and lunar ephemeris. The SKYMAP program uses only the solar ephemeris; therefore, it accesses SUNMUN through the entry point POSSUN.

36.	UNITV	Computes the unit vector of a three-dimensional vector.
37.	UNLOAD	Dismounts a tape volume; an FTIO routine.
38.	XRTAPE	Fills in a COMMON block and writes its contents to the output XRATES tape for each acceptable record of the input tape.
39.	YSRCES	Compiles a list of X-ray sources which can be observed by the spacecraft during a revolution.

SUBROUTINE CROSS REFERENCE CHART

Figure 2-3

Calling Routines \ Called Routines	CLEAN	CONECL	CONVEC	CONVER	CROSS	CVXYZ	DIGIT	DOT	ECOUNT	EOCC	EPHEM	FOVIEW	HEADER	INIT	JDAY	MAPTAP
CONVEC					●			●								
EOCC			●			●						●				
EPHEM															●	
FOVIEW								●								
INIT																
MAIN	●						●						●	●		
MAPTAP																
MFOV			●			●										
PHATAP																
PROG1		●	●	●		●		●			●					
PROG2									●	●						●
SCANGL					●	●		●								
SINFOV						●										
SPFLAG						●		●								
SRCLOC			●					●								
SUMOUT																
XRTAPE																
YSRCES						●		●								

Calling Routines \ Called Routines	MFOV	NOMINL	PHATAP	PROG1	PROG2	SCANGL	SCLEAN	SINFOV	SPFLAG	SRCLOC	SUMOUT	SUNMUN	UNITV	XRTAPE	YSRCES
CONVEC													●		
EOCC													●		
EPHEM												●			
FOVIEW															
INIT											●				
MAIN				●	●						●				
MAPTAP						●									
MFOV													●		
PHATAP						●									
PROG1						●							●		●
PROG2	●	●	●				●	●	●					●	
SCANGL													●		
SINFOV										●					
SPFLAG						●									
SRCLOC															
SUMOUT															
XRTAPE															
YSRCES															

FTIO ROUTINES

Calling Routines \ Called Routines	FREAD	FWRITE	MOUNT	POSN	REWIND	UNLOAD
CONVEC						
EOCC						
EPHEM						
FOVIEW						
INIT			●	●		
MAIN	●		●	●		●
MAPTAP						
MFOV						
PHATAP		●				
PROG1						
PROG2						
SCANGL						
SINFOV						
SPFLAG						
SRCLOC						
SUMOUT		●		●		
XRTAPE		●				
YSRCES	●				●	●

COMMON BLOCK CROSS REFERENCE CHART

Figure 2-4

Used by Routine \ Common Block	CONST	CONSTF	CURREC	DEBCOM	DETCOM	ELC	EOVFLG	FERMSG	FMOON	FOVCOM	INPARM	MAPCOM	MAPOUT	NOMCOM	PHAOUT	PRTSW	QLFLAG	SAVDIG	SCLASS	SUMMP	SUMMY	SUMPH	SUMXR	SUNCOM	TAPOUT	UPD	XRFLAG
BLKSKY	●	●	●		●	●				●	●	●	●		●	●				●	●	●	●			●	●
CLEAN			●						●							●		●			●						
CONECL	●																										
DIGIT																		●									
ECOUNT						●																					
EOCC		●	●																								
FOVIEW					●					●																	
HEADER																●											
INIT	●								●		●					●		●		●	●	●	●			●	●
MAIN							●	●			●					●	●	●			●						
MAPTAP			●								●	●		●		●		●			●			●			
MFOV			●						●							●					●						
NOMINL				●																							
PHATAP			●						●		●	●	●	●	●	●		●			●	●		●			
PROG1	●		●								●		●			●	●		●	●	●	●		●		●	●
PROG2			●						●		●			●		●					●			●			
SCANGL	●																										
SCLEAN			●						●							●		●									
SINFOV			●																●								
SPFLAG			●																								
SUMOUT			●				●					●	●		●	●				●	●	●	●			●	
XRTAPE			●						●		●		●	●		●		●			●		●		●		
YSRCES	●																										●

2.3.1 PRIMARY CONTROL SECTION - MAIN

The SKYMAP program begins with a call from MAIN to subroutine INIT which sets default values for variables not initialized by the BLOCKDATA section, reads input parameters, sets the associated control switches, and mounts and positions any output tapes requested by the user. The MAIN routine then mounts and positions the input MAX tape. All tape and disk accesses are accomplished by using the SACC IBM S/360 FTIO system library routines FREAD, FWRITE, MOUNT, POSN, REWIND, and UNLOAD. Each time a MAX volume is mounted, subroutine HEADER prints the information contained in the MAX tape header record.

Major frames are read into core until a major frame is reached whose time corresponds to a period later than the specified start time. The next two major frames are then brought into core as well. From this point on, SKYMAP maintains three major frames of data in core at all times. One major frame is the focal point of the analysis routines, while the two subsequent major frames are accessed by subroutines which test the current major frame.

2.3.2 PRIMARY CONTROL SECTION - PROG1

Subroutine PROG1 is called for every major frame of data occurring within the time interval to be processed. It is the only subroutine called when a major frame contains dummy data. PROG1 transfers the major fram data to the COMMON block CURREC used for processing, and returns to MAIN unless each of the following conditions is true:

1. Analysis of a data interval has just begun, or a new MAX file has been accessed which could contain a new nominal spin axis.

2. The present major frame is free of data gaps and has no missing attitude data (i.e., major frame does not contain dummy data).

If the user has not entered spin axis overrides, the satellite axis is calculated as the position of the Sun at the midpoint of the current 12 hour period defined from 2 AM (i.e., 8AM or 8 PM) is determined in subroutine EPHEM using the Julian day equivalent of the current day and time returned by subroutine JDAY and calculations performed in subroutine SUNMUN through entry point POSSUN. Subroutine CONVER converts the solar position to 1950 celestial coordinates and CONECL converts from celestial to ecliptic coordinates. Using this information, subroutine YSRCES defines a detector scan plan orthogonal to the spin axis and compiles a list of up to 75 X-ray sources within 4.3 degrees of the plane from the HEAO-A2 X-ray Source Catalog. If more than 75 sources are located within this band of the sky, only the first 75 sources are used and an error message is written. Returning, PROG1 corrects the intensity of each source for detector area using subroutine SCANL, with vector subroutines CVXYZ, DOT, CROSS, and UNITV to calculate the aspect angle perpendicular to the scan plane. If the MAP tape option has been selected, PROG1 extracts information for the MAP tape header before returning to MAIN.

The memory format of the current major frame determines subsequent subroutine calls by the MAIN routine. If the memory format is ROM1, ROM2, or RAM1-10, the major frame is considered to contain processable data. Except for the last two major frames in a MAX file, if the memory format is valid subroutine CLEAN is called next to determine the clean, DPU, and digital status for each of the six detectors. Since the digital status involves data contained in the two major frames following the current major frame, MAIN always sets the last two major frames of a MAX volume to "not clean" and subroutine CLEAN is not called.

2.3.3 PRIMARY CONTROL SECTION - PROG2

Subroutine PROG2 is called next, again only for valid memory formats. If the clean option has been specified by the user, PROG2 immediately returns to MAIN and no processing occurs, unless at least one detector (HED1-HED3, MED) was determined to be clean. For acceptable major frames, subroutine MFOV sets the moon-in-field-of-view flags for each detector, SCLEAN sets the superclean flags and ECOUNT calculates the electron contamination rate and sets the associated flag. Then subroutine EOCC sets the flags indicating whether the Earth plus atmosphere (either 100 km or 200 km) is within a detector's field-of-view, using subroutine FOVIEW to perform the actual field-of-view calculations. Subroutine SINFOV accesses the X-ray source subcatalog compiled earlier, calls subroutine SRCLOC to determine if a given source location is within the field-of-view of any of the detectors during any portion of the major frame, and sets flag HSFOV accordingly. Finally, the pointing flag is set in subroutine SPFLAG. For detailed descriptions of the methods involved in calculating the above flags, refer to Appendix A.

The remaining processing by PROG2 depends on the output tapes selected by the user. If a PHA tape is desired, subroutine PHATAP is called. PHATAP collects the information for the output data record and writes it to the tape. Likewise, if an XRATES tape has been requested, subroutine XRTAPE processes the output record. Both PHATAP and XRTAPE check for major frames in engineering format, and such data is not output.

Subroutines NOMINL and MAPTAP are called only when the user has requested a MAP tape and the major frame is in scan mode. NOMINL handles the definition of the major frame status through tests of the experiment gas pressure, power, etc. (refer to Appendix A8). Unlike subroutines PHATAP and XRTAPE, subroutine MAPTAP does not perform the actual transfer of data to the output tape. Instead, MAPTAP checks the various data flags previously obtained, and, for valid major frames, sorts each 1.28 second readout by detector into the appropriate scan angle bin. This completes the analysis for a major frame.

Before processing a new major frame, the experiment and digital status are saved to be used later in determining experiment stability. This function is performed by subroutine DIGIT, which is called by MAIN for every major frame that does not contain dummy data, regardless of memory format.

Processing for successive major frames continues as above in accordance with the memory format until an end-of-file or end-of-volume is encountered on the input MAX tape. Subroutine SUMOUT is then called to collect and output data for the MAP tape and to position all output tapes to new files. When all files within a specified interval of time have been analyzed, an appropriate message is generated. Processing then either terminates, or continues with a call to subroutine INIT if more data intervals have been requested by the user.

Subroutines CVXYZ, DOT, CROSS, and UNITV are general-purpose, vector utility routines. Subroutine CONECL is a utility routine which performs a transformation to ecliptic coordinates. Refer to the High Energy Astronomy Observatory Satellite - A (HEAO-A2) First Look Analysis Program (FLAP) Document for further details on thes subroutines.

2.3.4 COMMON AREAS

The COMMON block usage chart is shown in Figure 2.4. COMMON blocks MAPOUT, PHAOUT, and TAPOUT contain the data to be written to the MAP, PHA, and XRATES tapes, respectively. COMMON block CURREC contains the major frame to be analyzed. A description of the variables in COMMON block CURREC can be found in Appendix B of the High Energy Observatory Satellite - A (HEAO-A2) FRAPPE Program Description and Operators' Guide.

SECTION 3 - OPERATOR'S GUIDE

3.1 SYSTEM REQUIREMENTS

Program SKYMAP can be accessed and run on either the IBM S/360-91 or S/360-75 computer. The FORTRAN code is contained in the disk file ZBAKT.SKYMAP.SORC. It is run from the disk load module ZBAKT.SKYMAP.LOADL member SKYMAP. The JCL necessary to run SKYMAP is stored in the TSO file ZBDAL.HEAO1.JCL (SKYMAP), which includes the JCL for the MAX input tape, source output tapes, and card data. Only the NAMELIST CARDIN and job run time need be edited for each submittal. The program requires approximately 550K bytes of core storage to execute. A SKYMAP run covering 20 days, using all defaults and generating the three types of tapes, uses approximately 15.5 minutes CPU and 13.6 minutes I/O time on the S/360-91. This varies according to the options chosen and data content. In general, 0.80 minute CPU and 0.70 minute I/O should be allowed for processing 1 day's data on the S/360-91.

3.2 JCL

The following is an example of the JCL and data for a run.

```
//ZBFLLSKY JOB (SB0181188J,T,HE0001,012012),BFB
// EXEC LINKGO,REGION=550K
//LINK.NEWLIN DD DSN=ZBAKT.SKYMAP.LOADL,DISP=SHR
//*   IF ZBAKT.SKYMAP.LOADL CANNOT BE FOUND ON DISK OR IN SYSTEM
//*       ARCHIVES, IT IS ON FILE 2 OF VERSION 3 OF TAPE XR0003
//*        LAST LOCATED IN BUILDING 2, ROOM 250 AT GSFC.
//*  TO RESTORE LOAD MODULE TO DISK, USE JCL IN THE TSO FILE
//*         ZBFLL.HEAD1.JCL(UNLOAD)
//LINK.SYSLIN DD *
  ENTRY MAIN
  INCLUDE NEWLIN(SKYMAP)
//SYSUDUMP DD SYSOUT=A
//GO.FT06F001 DD DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),SYSOUT=A
//GO.FT10F001 DD UNIT=(6250,,DEFER),LABEL=(,NL),DISP=(OLD,KEEP),
//                DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,BUFNO=2),
//                VOL=SER=DTAPE
//GO.FT11F001 DD DSN=ZBARS.XRAY.CATALOG,DISP=SHR,DCB=(BUFNO=2)
//GO.FT20F001 DD UNIT=(6250,,DEFER),LABEL=(1,NL),DISP=(OLD,KEEP),
//               DCB=(RECFM=FB,LRECL=5952,BLKSIZE=5952,BUFNO=2,DEN=4),
//               VOL=SER=DTAPPH
//GO.FT30F001 DD UNIT=(6250,,DEFER),LABEL=(,NL),DISP=(OLD,KEEP),
//                DCB=(RECFM=FB,LRECL=25968,BLKSIZE=25968,BUFNO=2,DEN=4),
//                VOL=SER=DTAPMP
//GO.FT40F001 DD UNIT=(6250,,DEFER),LABEL=(,NL),DISP=(OLD,KEEP),
//                DCB=(RECFM=FB,LRECL=5048,BLKSIZE=5048,BUFNO=2,DEN=4),
//                VOL=SER=DTAPXR
//* THIS MUST BE AN UNNUMBERED TSO FILE, ELSE NAMELIST CARDIN WILL
//* NOT BE READ IN CORRECTLY TO PROGRAM SKYMAP.
//GO.DATA5 DD *,DCB=(BUFNO=2)
 &CARDIN DTAPE='XR0351',IDAY2=226,ITIM2=50400000,DTAPPH='XR0021',
 DTAPMP='XR0022',DTAPXR='XR0023',OLAST=.TRUE.,
 &END
// EXEC NOTIFYTS
```

3.3 INPUT DATA

Input to SKYMAP consists of a MAX tape, an X-ray source catalog, and a set of parameters to be read from cards.

The MAX tape is a 9-track, 6250 bpi, no label magnetic tape produced by program FRAPPE. Refer to the High Energy Astronomy Observatory Satellite - A (HEAO-A2) FRAPPE Program Description and Operator's Guide for more details. The X-ray source catalog is stored on disk with the file name ZBARS.XRAY.CATALOG.

Card input is as follows:

1. The first data read in is the NAMELIST CARDIN, which must have the following format. The first card must begin with b̸&CARDINb̸ followed by data items. The end of the NAMELIST is signalled by b̸&END. A data item consists of a variable name, followed by an equal sign, the value to be assigned to that variable, and a comma. The data items may appear in any order, and as many cards as necessary may be used, but each card must have a blank in column one. A description of the variables in NAMELIST CARDIN follows:

Variable	Type	Description and Default (if any)
DTAPE	R*8	Volume serial number of MAX tape (must be in quotes; e.g., DTAPE='XR0001')
NFILE	I*4	File number on MAX tape where processing is to begin. Default: 1

Variable	Type	Description and Default (if any)
IDAY1	I*4	Start day of selected interval. Default: 0 (indicates that processing is to commence at the beginning of the input file).
ITIM1	I*4	Start time of selected interval in milliseconds. Default: 0 (beginning of tape)
IDAY2	I*4	Stop day of selected interval. Default: 999 (indicates that processing is to terminate when an end-of-volume occurs on the input tape).
ITIM2	I*4	Stop time of selected interval in milliseconds. Default: 99999999 (end of volume).
QCLEAN	L*1	Indicates whether only "clean" data is to be written to output tapes. Default: .TRUE.
NSPIN	I*4	Number of spin axis overrides (which follow NAMELIST data). Each override is associated with a MAX file if NSPIN $\neq \phi$; therefore, it must equal the number of MAX files to be processed. Default: 0

Variable	Type	Description and Default (if any)
ISCLAS	I*4	X-ray source classification selection flag. Note: All sources with class ≤ ISCLAS are to be considered for acceptance. Default: 999 (all sources are to be considered for acceptance).
QPHA	L*1	Indicates whether a PHA tape is to be produced. Default: .TRUE.
DTAPPH	R*8	Volume serial number of output PHA tape (must be in quotes; e.g., DTAPPH='XR1234').
NFILPH	I*4	File number on PHA tape where writing is to begin. Default: 1
QMAP	L*1	Indicates whether a MAP tape is to be produced. Default: .TRUE.
DTAPMP	R*8	Volume serial number of output MAP tape (must be in quotes, e.g., DTAPMP='XR378').
NFILMP	I*4	File number on MAP tape where writing is to begin. Default: 1
QXRT	L*1	Indicates whether an XRATES tape is to be produced. Default: .TRUE.

Variable	Type	Description and Default (if any)
DTAPXR	R*8	Volume serial number of output XRATES tape (must be in quotes; e.g., DTAPXR='XR002').
NFILXR	I*4	File number on XRATES tape where writing is to begin. Default: 1
QLAST	L*1	Indicates if there are no more input data cards to be read. Default: FALSE

2. Following the NAMELIST input, the nominal spin axis position overrides are read in if NSPIN was greater than zero. These should appear one per card in the following format:

Columns 1-8	Right ascension of spin axis in degrees (format F8.3)
Columns 9-16	Declination of spin axis in degrees (format F8.3)

The first spin override card will be associated with the first MAX file read (NFILE); the next MAX file will use the next spin override, etc. There must be NSPIN spin override cards.

If more intervals of data are to be processed, the entire sequence of input data (NAMELIST and spin override cards) may be repeated as many times as desired. The final set of NAMELIST CARDIN input data cards should contain QLAST=.TRUE (or simply QLAST=T).

3.4 OUTPUT DATA

SKYMAP output consists of up to three types of magnetic tapes, a summary printout, and error messages.

3.4.1 TAPES

There is an output tape for each tape option selected by the user. For the SKYMAP program, the three tapes are PHA, XRATES, and MAP. Details concerning tape record formats and contents are given in Appendices C, D, and E, respectively. The output tapes are 9-track, 1600-bpi magnetic tapes.

3.4.2 STANDARD PRINTOUT

Within a single job submittal, the user may request that data for several time intervals be processed. Each time a new interval is started, the user input parameters are echo-printed. The internal switches set as a result of the data selection switches which were read in are also printed. The header record of the input MAX tape containing the volume number of the original MAX tape, the IPD tapes from which it was generated, its starting date, and a flag indicating whether it is a Quicklook or Production MAX tape, is printed.

The CELECT coefficients to be used in setting the electron contamination flag are written from subroutine ECOUNT the first time it is called. Similarly, once per submittal, subroutine SRCLOC outputs the TOP and BOTTOM field-of-view angles for each detector before and after adjustments.

Two sets of information are printed each time the X-ray source listings file is udpated: the Sun's position (right ascension and declination) in 1950 coordinates, as calculated or from spin overrides, followed by a listing of all the sources which can appear in the spacecraft's field-of-view, given the current Sun position.

A message is written to the printer when a data interval has been processed. The day and time of the current major frame, number of records within the interval, and the number of records processed are contained in the statement. This same information as well as the tape and volume number, is written when an end-of-volume is reached on the input MAX tape.

The MAIN routine also generates a message each time an end-of-file occurs on the MAX tape containing the file number and total number of records read into core. The record count does not include the second record of each MAX file, since that record is assumed to contain fill data and is ignored. Each time processing of a MAX file is completed the contents of NAMELIST SUMW are printed. The NAMELIST contains the day and time of the current major frame (expressed together as a real number, and separately as integers), day and time of the last major frame used to update the X-ray source listing, a logical flag indicating whether this is the final call to SUMOUT, the value of the flag which signals for the X-ray source listing to be updated, the logical end-of-volume flag, and the day and time of the next major frame in core.

When all data intervals have been processed, the volume number, ending file number, total number of records, and number of I/O errors are printed for each output tape. Execution is terminated with the message PROCESSING OF MAX VOLUMES COMPLETED. This final message does not indicate that the job ran successfully. No processing may have occurred due to user input errors, yet the message will still be printed. The only time a SKYMAP printout will finish without the PROCESSING OF MAX VOLUMES COMPLETED message is when the program terminates due to excessive I/O errors.

3.4.3 SPECIAL MESSAGES

If there are no sources in the spacecraft's field-of-view for the current spin position, subroutine YSRCES prints the message:

> NO XRAY SOURCES IN FIELD OF VIEW FOR CURRENT SPIN AXIS. RT. ASC. AND DECLINATION OF SPIN AXIS ARE (gives the RA and DEC)

Subroutine PROG2 writes the start and end time and the y-axis position for each point. This information is written on unit 8 which is allocated to the printer and appears after all normal printout. The statement is

> START POINT AT (day, time), YRA, YDEC = (first minor frame readout of y-axis RA and DEC), END POINT AT (day, time).

For every output MAP tape file, the NAMELIST MAPO is also written to the printer. MAPO is the data stored in the MAP tape header record: the start day and time of the MAP file, the end day and time, record type (0 for general data), PHA file number corresponding to this MAP file (0 if there is no PHA tape for this run), spin axis index, Sun right ascension and declination at start of the file, and two spares, each having a value of zero.

3.4.4 ERROR MESSAGES

If too many spin overrides are entered by the user, the error message is

> ERROR IN NUMBER OF OVERRIDES

Whenever the sum of the number of spin overrides and the starting MAX file number, is greater than 21, subroutine INIT prints the preceding message, and sets a flag which results in termination of program execution.

If there is an error in the input times, the error message will be

TIME INTERVAL ERROR: DAY OR TIME TOO LARGE

Subroutine INIT generates this message when the user-entered starting time is greater than 86400000, or when both the start and end days equals zero. Program execution is terminated by MAIN when this condition exists.

If an I/O error occurs while accessing the input MAX tape, the following will be printed along with the standard FTIO error message:

I/O ERROR ON RECORD (record number) FILE NUMBER (file number), MAX VOLUME (volume name).

If the number of I/O errors is less than 10, another major frame is read into core and processing continues as normal; otherwise, processing is terminated. Refer to the FTIO - FORTRAN I/O package for a description of the contents of the second message

Current dimensions allow storing only 75 sources when compiling a list of all the X-ray sources which can be in the spacecraft's field-of-view during the current revolution. For this reason, whenever more than 75 sources are found, subroutine YSRCES prints the following message for each X-ray source which will be in the field-of-view, but cannot be included in the source listing due to space limitations.

*** TOO MANY SOURCES *** NAME DELETED = (source name) AT RT. ASC. & DEC. (source position) RADIANS, # OF SOURCES = (75).

Program execution continues as normal.

If an I/O error occurs while reading the X-ray source catalog from disk, subroutine YSRCES prints the message:

ERROR READING X-RAY SOURCE DISK FILE

Control is immediately returned to subroutine PROG1, and job execution continues with a possibly incomplete source list.

If 1000 or more records can be read from the X-ray source disk file, subroutine YSRCES generates the message:

TOO MANY RECORDS ON X-RAY SOURCE DISK FILE

Currently, the disk file contains less than 500 sources; therefore, this message will appear only if the X-ray source catalog is ever increased past 1000 sources. When the latter occurs, this message will be a signal that subroutine YSRCES did not check each source to determine whether it was in the spacecraft's field-of-view.

If a scan angle is outside its proper range, the array index for storing MAP data will be also. For this reason subroutine MAPTAP generates the message:

INDX IS OUT OF RANGE AT (day and time) INDX =
(a number < 1 or > 1440) SCAN ANGLES ARE AS FOLLOWS
(the 32 scan angle values for the current major frame)

It is extremely unlikely the preceding will ever occur; however, program execution continues even though an SOCO error may result.

APPENDIX A - FLAG CALCULATIONS

A1. ELECTRON CONTAMINATION FLAG (HECON)

Programs FRAPPE and SKYMAP both produce an electron contamination flag. The flag generated by the SKYMAP program differs from the one produced by the FRAPPE program in several ways. First, SKYMAP leaves the section of the flag pertaining to the LED1 and LED2 detectors as it was set by program FRAPPE. (For a description of the method used by the FRAPPE program, refer to Section 2, pages 9-11 of the HEAO-A2 FRAPPE Program Description and Operator's Guide.) When determining whether the HED1, HED2, MED, and HED3 detectors are electron-contaminated, the SKYMAP program sets a lower limit of -500 for the electron rate. SKYMAP also sets a special superclean electron rate limit for the MED detector which is then used in subroutine MAPTAP in deciding whether to accumulate superclean data for the MED detector.

The electron rate is calculated as follows:

For detectors HED2 and MED (i=2 and i=3 respectively)

$$n_i = h_{9_i} + t_1 h_{9_i}^2 - b_i (h_{8_i} + t_2 h_{8_i}^2 - c_i)$$

For detectors HED1 and HED3 (i=1 and i=4 respectively)

$$n_i = h_{9_i} + t_1 h_{9_i}^2 - b_i (h_{7_i}^2 + t_2 h_{7_i}^2 - c)$$

where h_{7_i}, h_{8_i}, h_{9_i} are the absolute values of the seventh, eighth, and ninth housekeeping scalers for the i^{th} detector, and

$t_1 = 2.7 \times 10^{-7}$

$t_2 = 7.3 \times 10^{-8}$

b_i = constants dependent on detector

$b_1 = .80$

$b_2 = 1.51$

$b_3 = 1.42$

$b_4 = .86$

$$c_i = c^1_i \, e^{(d_i - d)/1422}$$

where c^1_i = constants dependent on detector

$c_1{}^1 = 691.00$

$c_2{}^1 = 805.27$

$c_3{}^1 = 763.90$

$c_4{}^1 = 1093.22$

d_i = day at which strength all of calibration sources were measured, with day 1 being January 1, 1977

$d_1 = 70$

$d_2 = 70$

$d_3 = 70$

$d_4 = 70$

d = current day based on January 1, 1977

(NOTE: The ten housekeeping scalers are listed on page 53 and defined on pages 30-52 of the HEAO-A2 Cosmic X-Ray Experiment Technical Manual.)

If the absolute value of housekeeping scaler 9 is greater than 30000, or the electron rate is less than -500 or is greater than the predetermined limit, the flag is set to "contaminated" for that detector. The limits for each detector are

HED1 : 1000
HED2 : 700
MED : 1200
HED3 : 500
MED (superclean) : 600

The preceding standards apply when ther is no fill data in the seventh housekeeping scaler (when testing HED1, HED3) or in the eighth housekeeping scaler (when testing HED2, MED). If the absolute value of housekeeping scaler 9 is less than 30000 and the applicable seventh or eighth housekeeping scaler is fill data, the flag for the detector is set as having no electron contamination. The constants and limits for the MED and HEDs are the result of a study of experiment data by Dr. A. Rose of GSFC.

The format of the electron contamination flag is

2**1, 2**0 bits = LED1
2**3, 2**2 bits = LED2
2**5, 2**4 bits = HED1
2**7, 2**6 bits = HED2
2**9, 2**8 bits = MED
2**11, 2**10 bits = HED3
2**12 bit = MED superclean

bits = 00 = no electron contamination
bits = 11 = electron contamination

A2. CLEAN FLAG (HCL)

Clean status is determined for major frames having a ROM or RAM 1-10 memory format. The data for a detector is described as being "clean" if two sets of criteria are met. The first set relates to the major frame. It must contain no bit errors or block encoder errors (test flag HERRF). Fill data is accepted when due to a toggle (i.e., change in memory format), provided no error flags are set in data record 1 of the current and next major frame [test array QERR1(128)]. The second set of criteria applies to each detector. These requirements are that

1. The detector's field-of-view excludes the Earth plus 100-km atmosphere (test flag HEOCC2 as set by program FRAPPE).
2. The high voltage for the detector is on and not within two frames of turn on (test flag HVFLAG).
3. The detector's high voltage is stable; i.e., changing by less than 2.0 volts over the three major frames centered on the present data, and within 4.0 volts of a specified value (test flag HVST).
4. The detector's field-of-view excludes the calibration source rods [test flag QDSTAT(15)].
   NOTE: This test applies only to the LED1, LED2, and MED detectors.

The format of the clean flag is

2**0 = LED1

2**1 = LED2

etc.

where: bit = 1 = clean

bit = 0 = not clean

A3. SUPERCLEAN FLAG (HSUPCL)

When a detector is described as "superclean" it satisfies the following set of criteria:

1. The detector is clean.
2. The detector's field-of-view excludes the Moon. (Refer to Section on "Moon in field-of-view" in this appendix.)
3. Detector has no discovery scaler least significant bit (LSB) overflows. This is ascertained by summing four 1.28-second readouts and comparing them to the corresponding 5.12-second readout. If the two are equivalent, no LSB overflow have occurred. Since a major frame is 40.96 seconds in length, there are eight such sets of comparisons to be made for each major frame.
4. The detector's first four discovery scaler rates are constant, as determined in the following manner:
    (a) For each 1.28-second sample, add the first four discovery scalers. There are 32 samples per major frame.
    (b) Once step (a) is completed, calculate the mean, μ, and the variance, σ^2.
    (c) Data is constant if $\sigma^2 \leq 1.3\mu$.

The superclean flag is defined for each detector as follows:

2**0 = LED1
2**1 = LED2
etc.

where: bit = 1 = superclean
bit = 0 = not superclean

A4. SOURCE IN FIELD-OF-VIEW FLAG (HSFOV)

The source-in-field-of-view flag is calculated using routines developed to select data within a major frame, for which a given source is to be seen in a particular detector. The needed information for the determination is

1. The source unit vector in celestial coordinates ($\vec{S}$).
2. The spacecraft y- and z-axis celestial coordinates at the ends, inclusive, of the time of interest.
3. The time interval covered, in units of 1.28 seconds.

For a given source, a rough check is first made to see that the source is within 4° of the scan plane; i.e.,

$$|\vec{S} \cdot \vec{Z}| \leq 0.0697$$

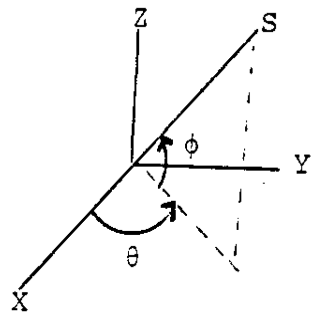
and that the source is within 20° of either the first or last y-axis, i.e., for at least one $\vec{y}$:

$$\vec{S} \cdot \vec{Y} > 0.93969$$

If either of these tests fails, the source cannot be in the field-of-view of any detector.

For sources which pass these tests, the source location (angles) in spacecraft coordinates is calculated for the two given spacecraft attitudes.

The two angles used are θ and φ, as seen here.



where S is the source direction, and x, y, and z are the spacecraft axes.

Using the two pairs of angles and the time interval included, the average rates of change for θ and ϕ are calculated and used to extrapolate to the actual start and end of the data accumulation interval. This is done using the fact that the first attitude data corresponds to a time 0.96 seconds after the start of a discovery scaler or PHA accumulation, while the last attitude corresponds to a time 0.32 seconds before the end of an accumulation. For a major frame calculation, the start of the major frame is 0.96 seconds before the time of the first attitude data, and the end is 0.32 seconds after the last attitude data.

For the normal scan data, these extrapolations are valid, and it should be noted that the source will move with time in the direction of decreasing θ. For each detector the following tests are made to decide if the source is observed.

1. If both values of ϕ are larger than the largest ϕ for the detector, the source is not observed.

2. If both values of ϕ are smaller than the smallest value of ϕ for the detector, the source is not observed.

3. If both values of θ are larger than allowed for the detector, the source is not observed.

4. If both values of θ are smaller than allowed for the detector, the source is not observed.

If none of these conditions are met, the source is considered to be observed. This is a conservative approach in that any data not flagged with a source observed certainly is source-free. Some data flagged for a source will have no exposure in the detector, but only a very small fraction of the time for scan mode.

The set of four tests is applied first for the large field-of-view of each detector, and if the source is observed here, the tests are repeated for the small field-of-view. Separate flags are set for each detector and each field-of-view.

The flag, HSFOV, is the logical OR of the above tests done for the set of all catalog sources within 4.3° of the nominal scan plane. The flag is a 2-byte integer with the following bit determinations.

2**2	bit = 1	if source in HED1	Large FOV
2**3	bit = 1	if source in HED2	Large FOV
2**4	bit = 1	if source in MED	Large FOV
2**5	bit = 1	if source in HED3	Large FOV
2**10	bit = 1	if source in HED1	Small FOV
2**11	bit = 1	if source in HED2	Small FOV
2**12	bit = 1	if source in MED	Small FOV
2**13	bit = 1	if source in HED3	Small FOV

A5. EARTH OCCULTATION FLAGS (HEAR1 and HEAR2)

The Earth occultation flags indicate, for each detector, whether the Earth is in the field-of-view of that detector for any part of the major frame. The first occultation flag (HEAR1) is set if any part of the Earth plus 200 km of atmosphere is in the field-of-view, while the second flag (HEAR2) is set if the Earth plus 100 km of atmosphere is in the field-of-view.

The occultation calculation is performed using the satellite altitude, satellite velocity vector, and satellite geocentric coordinates (all of which are available once per major frame), along with the spacecraft attitude data, (available 32 times per major frame). Three sample times are used in the process of setting the flags: the start time of the major frame (STOMF), STOMF plus 20.48 seconds, and STOMF plus 38.40 seconds. For each of these three times, the horizon angle from the center of the Earth as viewed from the spacecraft, is calculated for the Earth plus 200 km, and for the Earth plus 100 km. The celestial coordinates of the center of the Earth from the spacecraft are also calculated for these three times, assuming a circular spacecraft orbit and constant speed for the major frame. The Earth horizon angle is given by

$$\sin \phi = (R_o + a)/(R_o + h)$$

where ϕ is the Earth horizon angle
R_o is the Earth radius
a is the thickness of the atmosphere
h is the satellite altitude

Then using the spacecraft attitude data, a calculation is made to check if any portion within the Earth horizon is in the large field-of-view of the detector at these three times. If the earth is observed for any of these times, the data are determined to be occulted for that detector, and flag is set.

The format of the occultation flag is

HEAR1, HEAR2 = 0 no detector occulted

2**0 bit set = LED1 occulted
2**1 bit set = LED2 occulted
2**2 bit set = HED1 occulted
2**3 bit set = HED2 occulted
2**4 bit set = MED occulted
2**5 bit set = HED3 occulted

A6. POINTING FLAG (HPT)

For a given major frame, the spin axis flag indicates whether the spin period is nominal, and whether the spacecraft's spin axis is within 2° of the Sun's position at the start of the current file. The spin period is defined as nominal if the ecliptic scan angle of the spacecraft y-axis changes by 5° to 9.5° within the time period of the major frame. The ecliptic scan angle is defined by

$$\text{SCAN ANGLE} = \text{TAN}^{-1} [(\bar{Y}\cdot\bar{N})/(\bar{Y}\cdot(\bar{N}\times\bar{Z}))]$$

where $\bar{Y}$ = actual y-axis unit vector
$\bar{N}$ = north ecliptic pole unit vector
$\bar{Z}$ = nominal spin axis unit vector.

The ecliptic scan angle is calculated twice in order to determine the change. For each major frame, there are 32 minor frame readouts, each containing the right ascension and declination of the spacecraft's spin axis and y-axis. SCAN ANGLE$_1$ is calculated using the spin axis and y-axis positions found in the first minor frame; similarly, scan angle$_2$ is generated by incorporating the positions in minor frames 32. If

$$5.0° \leq \text{SCAN ANGLE}_2 - \text{SCAN ANGLE}_1 \leq 9.5°$$

the satellite's spin period is described as nominal.

The equation for determining whether the spacecraft's spin axis is within 2° of the Sun's position at the start of the file is

$$\text{ANG} = \text{COS}^{-1} (\bar{Z}\cdot\bar{S})$$

where $\bar{Z}$ = current spin axis unit vector (derived using the spin axis position from minor frame 1)

$\bar{S}$ = unit vector from Earth to Sun

ANG = the angle between the two vectors

If ANG is less than 2° the spin axis is within 2° of the Sun.

The format of the spin-axis flag (HPT) is

bit 2**0 = 0 spin period is nominal
         = 1 spin period is not nominal

bit 2**1 = 0 spin axis is within 2° of Sun
         = 1 spin axis is not within 2° of Sun

When HPT = 0, the satellite is described as being in scan mode; otherwise, it is referred to as being in pointing mode.

A7. DIGITAL STATUS FLAG (HDIG)

The digital status flag is a dual-purpose flag. It indicates both the DPU and the digital status of each detector in a major frame. In order for a detector's DPU status to be "not changing", the following criteria must be met:

1. The next major frame must have the same memory format as the current major frame.

2. The detector's DPU status must be identical for the current and next major frames.

A discussion of what information comes under the heading of DPU status can be found in Section 2, pages 14-15 of the HEAO-A2 FRAPPE Program Description and Operator's Guide.

The criteria for setting the digital status portion of the flag is not as straightforward as it is based on both experiment and detector digital status. Each major frame contains a full cycle of experiment status information, but only a half cycle of detector digital status data. When the major frame count is even, the digital status section contains information on the LED1, LED2, and HED1 detectors. HED2, MED, and HED3 digital status information is contained in odd major frames. For purposes of the digital status flag, a detector's digital status is described as "not changing" when it satisfies the following criteria:

1. The experiment digital status must be constant for the previous, current and next major frames.

2. The detector's digital status must be constant from the preceding to the succeeding major frame. This may or may not include the current major frame, depending on the detector and the major frame count.

In order to perform the preceding tests, the SKYMAP program is designed to retain in core the experiment status of the previous major frame and the digital status readouts from the two previous major frames. This, combined with the three major frames in core at all time, provides five major frames of digital status information and four of experiment status.

Using the array QDSTAT(64) to represent the digital status information present in a major frame, the following elements are used in the process of setting the digital status flag:

1. For experiment digital status

   QDSTAT(13-19)

   QDSTAT(24)

   QDSTAT(25) bits 2**4 through 2**7 only

2. For detector digital status

   QDSTAT(26 + 13n) through QDSTAT(38 + 13n)
   except: QDSTAT(32 + 13n) bits 2**4 - 2**15
   QDSTAT(33 + 13n) bits 2**0 - 2**3 and
   bits 2**8 - 2**15

   where n = 0, 1, 2 and represents the three detectors whose digital status is in the current major frame.

There is a one-to-one correspondence between the array QDSTAT and the DSM word numbers appearing in the third column of the Digital Housekeeping Table on pages 127-145 of the <u>HEAO-A2 Cosmic X-Ray Experiment Technical Manual</u>. Each DSM word number is 1 less than the corresponding element in array QDSTAT. QDSTAT(11) and QDSTAT(12) contain telemetry data; hence, they are not defined in the Digital Housekeeping section of the manual; QDSTAT(37), QDSTAT(38), QDSTAT(50), QDSTAT(51), QDSTAT(63), QDSTAT(64) are spares and are also absent from the table.

The format of the digital status flag is

    2**1, 2**0 = LED1
    2**3, 2**2 = LED2
    etc.

where, for the two bits for each detector,

    the LSB represents the DPU status
    the MSB represents the digital status

    bit = 0 = no change
    bit = 1 = changing

A8. NOMINAL STATUS FLAG [HNOM(2,6)]

The nominal status flag is used to define the overall experiment status for both Discovery Scaler and PHA/Temporal data. Only detectors in major frame formats, ROM1, ROM2, RAM1, RAM9, and RAM10 are eligible for nominal status. Detectors LED1 and LED2 are always set as "not nominal." The various DPU and digital status flags from the input MAX tape used in determining the status of a given detector are detailed in Table A-1. QDPU(6) contains the DPU status for a major frame for each of six detectors. QSTATE(25) and QSTATD(13,6), in that order, are used to reference array QDSTAT(64) containing the experiment and detector digital status as defined in the section concerning the digital status flag.

The nominal status of every detector is determined each major frame. If no digital status readouts for a detector are available within the current major frame, the detector's digital status readouts from the previous major frame are used.

The format of the Nominal Status flag HNOM(2,6) is

HNOM(1,ID)	=	0 indicates that the detector is not in a nominal Discovery Sclaer state
	=	1 indicates that it is
HNOM(2,ID)	=	0 indicates that the detector is not in a nominal PHA/Temporal state
	=	1 indicates that it is

Table A-1. Criteria for Determining Nominal States

Part 1: Criteria Common to Both the Nominal Discovery Scaler State and the Nominal PHA/Temporal State

Definition	Member		Required Value of Each Bit	Restrictions (if any)
HED1 Propane-Veto Pressure	QSTATE(18)	bit 1	0	HED1 only
HED2 Propane-Veto Pressure	QSTATE(18)	bit 0	1	HED2 only
MED Calibration Source Rod	QSTATE(15)	bit 3	0	MED only
Analyze V2 (C28)	QSTATD(3,ID)	bit 7	0	MED only
HED3 Propane-Veto Pressure	QSTATE(19)	bit 7	0	HED3 only
Analyze Alpha (C28)	QSTATD(8,ID)	bit 0	0	HEDs only
High Voltage Power	QSTATD(1,ID)	bit 4	1	
Test Pulse Generator Power	QSTATD(1,ID)	bit 5	0	
Low Voltage Detector Power	QSTATD(1,ID)	bit 6	1	
Layer 1 (Right and Left) and Layer 2 (Right and Left) Thresholds	QSTATD(2,ID)	bits 0-7	0	
Veto Layers 1 and 2 Thresholds	QSTATD(3,ID)	bits 0-3	0	
Layer 2 Event Definition	QSTATD(3,ID)	bits 4-6	0	
Layer 1 (M1) and Layer 2 (M2) Thresholds	QSTATD(5,ID)	bits 0-3	0	
PHA Mode (C27)	QSTATD(5,ID)	bit 4	0	

Table A-1 (continued). Criteria for Determining Nominal States

Part 2: Additional Tests for Determination of Nominal Discovery Scaler State

Definition	Member		Required Value of Each Point
Layer 2 PHA window definition	QSTATD(4,ID)	bits 4-5	0
Discovery Scalers 7 and 8 definition	QSTATD(6,ID)	bit 3	1
Discovery Scalers 5 and 6 definition	QSTATD(6,ID)	bit 7	1
Layer 1 PHA window definition	QSTATD(8,ID)	bits 4-7	0
Discovery Scaler MSB readout time	QDPU(ID)	bit 3	0

Part 3: Additional Requirements for Determination of Nominal PHA/Temporal State

a) If the major frame is in ROM2:

Delta T computer mode	QDPU(ID)	bits 4-5, and 7	1
Multiscaler Rate Combination	QSTATD(9,ID)	bits 0-3	0

b) If the major frame is in ROM1, RAM10 (detectors HED1, MED, HED3), or RAM9 (detector HED2):

Layer 2 PHA window definition	QSTATD(4,ID)	bits 4-5	0
Layer 1 Event definition	QSTATD(5,ID)	bits 5-7	0
Dead Time Select	QSTATD(7,ID)	bit 1	0
Layer 1 PHA window definition	QSTATD(8,ID)	bits 4-7	0
PHA LSB/MSB readout times	QDPU(ID)	bits 1-2	0

c) If the major frame is in RAM1, RAM10 (detector HED2), or RAM9 (detectors HED1, MED, HED3):

The criteria in a) and b) with the exception that for RAM1 (all detectors) and RAM10 (detector HED2), QDPU(ID) bits 1-2 must each equal one.

A9. MOON-IN-THE-FIELD-OF-VIEW FLAG

One of the conditions for superclean data is that a given detector not be occulted by the moon during the major frame.

For each major frame, the vector from the Earth to the Moon [ODATA(13) - ODATA(15)] and the vector from the Earth to the spacecraft [ODATA(1) - ODATA(3)] are given. From these two vectors, the vector from the spacecraft to the Moon is derived. The vector is then expressed in spacecraft coordinates by using the spin-axis and y-axis readouts in minor frame 1 of the current major frame. (The components of the resulting vector from the spacecraft to the Moon are stored in members XM, YM, and ZM on the output PHA and XRATES tapes.) If the absolute value of the angle the Moon forms with the scan plane is greater than 4°, no detector is occulted by the Moon during the major frame. Otherwise, each detector is tested to see if the Moon occults its large field-of-view. If it does, a flag is set to indicate that the detector is occulted by the Moon.

Spacecraft coordinates for the vector from the spacecraft to the Moon are recalculated and the scan angle and field-of-view tests are repeated. The spacecraft spin-axis and y-axis positions from minor frame 1 of the next major frame are used if the next major frame is not in RAM0 and if the current major frame does not contain fill data. If either of the latter two cases occur, data from minor frame 32 (for RAM0) or minor frame 31 (for fill data) are used to redefine the vector from the spacecraft to the Moon. Data from minor frame 32 are also used when processing the last major frame on a MAX volume.

APPENDIX B - SCAN ANGLE [ESCAN(32)] CALCULATIONS

Calculated for each major frame, the array ESCAN(32) contains (in degrees) the angles the detector axis forms with the ecliptic plane based on the 32 readouts per major frame of the y-axis position. Each scan angle value is derived using the following equation:

$$\text{Scan angle} = \text{TAN}^{-1}\left[(\bar{Y}\cdot\bar{N})/(\bar{Y}\cdot(\bar{N}\times\bar{S}))\right]$$

where $\bar{Y}$ = actual y-axis unit vector

$\bar{N}$ = north ecliptic pole unit vector

$\bar{S}$ = unit vector from Earth to Sun (This vector represents the Sun's position at the start of the current file.)

APPENDIX C - PHA DATA BASE

INTRODUCTION

The PHA data base is a condensed version of the MAX data base containing PHA and discovery scaler data. Only major frames from MAX that are not in engineering format are included. Each PHA physical record contains data that was accumulated in one major frame (40.96 seconds) except the digital status which completes a cycle in two major frames, and the analog status which completes a cycle in eight major frames.

TAPE CHARACTERISTICS

TAPE ATTRIBUTES:

9-track, 1600 bpi when produced by program SKYMAP. IBM S/360 system procedure TAPESCAN is then used to condense the PHA tape to 6250 bpi.

FILE STRUCTURE:

Each production PHA file corresponds to approximately 12 hours of data. If no acceptable data exists for a 12-hour interval, no PHA file exists for the interval. Each tape contains no more than 40 files.

RECORD FORMAT:

Fixed length, blocked.

RECFM=FB,LRECL=5952, BLKSIZE=5952

DATA QUALITY

There are three checks made on the quality of data. A block encoder error indicates a transmission error from s/c to ground. A bit error indicates that 1 or more bits within a major frame have been improperly received. Fill data indicates that data for that minor frame is missing.

An overall data quality flag (HQUAL) is set to indicate if there were any block encoder errors, bit errors, or fill data anywhere in a major frame. Additionally, the data itself is made negative if there were bit errors, and the data is replaced with hexadecimal "aaaa" if there was fill data.

COMMON BLOCK DESCRIPTION

The COMMON block PHAOUT can be used to reference the PHA data base. A description of the variables follows:

Variable	Type	Description
LDAY	I*4	Day of major frame
LMSEC	I*4	Millisecond of major frame
HECON	I*2	Electron contamination flag 2**1, 2**0 = LED1 limit=600 2**3, 2**2 = LED2 limit=600 2**5, 2**4 = HED1 limit=1000 2**7, 2**6 = HED2 limit=700 2**9, 2**8 = MED limit=1200 2**11, 2**10 = HED3 limit=500 2**12 = MED superclean limit=600 bits=00=electron rate .le. limit bits=11=electron rate .gt. limit
HVF	I*2	High voltage flag 2**0 = LED1 2**1 = LED2 2**2 = HED1 2**3 = HED2 2**4 = MED 2**5 = HED3

Variable	Type	Description
		bit=0=high voltage on and not within two frames of turn on
		bit=1=high voltage off or within two frames of turn on
HSPAX	I*2	Spin axis index (1-720) Spin circle is divided into 720 half-degree bins
HFRM	I*2	Data format index If in ROM, = ROM number If in RAM, = RAM number +10
HMF	I*2	Major frame counter
HQUAL	I*2	Overall data quality flag
		2**0 = block encoder error 2**1 = bit error 2**2 = fill data
		bit=0=no error, bit=1=error
		NOTE: HQUAL = -4 when there is a gap in time between the present record and the next record.
HCL	I*2	Clean flag
		2**0 = LED1 2**1 = LED2 etc.
		bit=0=not clean, bit=1=clean
HSUPCL	I*2	Superclean flag
		2**0 = LED1 2**1 = LED2 etc.

Variable	Type	Description
		bit=0=not superclean bit=1=superclean
HVANOM	I*2	High voltage anomaly flag 2**0 = LED1 2**1 = LED2 etc. bit=0=stable bit=1=unstable
HASUN	I*2	SAA/NPA anomaly flag - also sunlight flag 2**0 = SAA/NPA bit=0=no SAA/NPA bit=1=SAA/NPA 2**1 = sunlight bit=0=no sunlight bit=1=sunlight
HJET	I*2	Number of jet firings during major frame
HSFOV	I*2	Source in field-of-view flag 2**0 = LED1 2**1 = LED2 etc. bit=0=no source in large field-of-view bit=1=source in large field-of-view

Variable	Type	Description
		2**8 = LED1 2**9 = LED2 etc. bit=0=no source in small field-of-view bit=1=source in small field-of-view
THETA	R*4	Rotation angle from S/C y-axis about S/C z-axis to center of earth ($-\pi$ to $+\pi$)
PHI	R*4	Angle from S/C z-axis to center of earth (0 to π) NOTE: Together THETA and PHI define a vector from S/C to center of Earth in S/C coordinates.
HEAR1	I*2	Earth occultation flag (including 200 km atmosphere) 2**0 = LED1 2**1 = LED2 etc. bit=0=no occultation bit=1=occultation
HEAR2	I*2	Earth occultation flag (including 100 km atmosphere) 2**0 = LED1 2**1 = LED2 etc. bit=0=no occultation bit=1=occultation

Variable	Type	Description
HPT	I*2	Spin axis flag 2**0 bit = 0 spin period nominal = 1 spin period not nominal 2**1 bit = 0 spin axis is within 2° of Sun = 1 spin axis is not within 2° of Sun
HDIG	I*2	Digital status flag 2**1, 2**0 = LED1 2**3, 2**2 = LED2 etc. where the two bits per detector represent LSB - DPU status MSB - digital status bit=0=no change bit=1=changing
STIME	R*4	Solar time (radians)
GLON	R*4	Geodetic longitude of s/c (rad)
GLAT	R*4	Geodetic latitude of s/c (rad)
ECNTR	R*4	Distance from s/c to Earth center (km)
AMACL	R*4	McIllwain L parameter
XB	R*4	x,y,z components of magnetic field in s/c coordinates
YB	R*4	
ZB	R*4	

Variable	Type	Description
XM	R*4	x, y, z components of Moon position in s/c coordinates (vector from Spacecraft to Moon)
YM	R*4	
ZM	R*4	
IDUM2	I*4	Spare
QSTATE(25)	L*1	Experiment status words
QSTATD(13,6)	L*1	Digital status words for six detectors
QDUM1	L*1	Spare
QSTATA(32,8)	L*1	Analog status words (32 words per major frame; 8 major frames to complete a cycle.)
QSTATC(6)	L*1	DPU status for each detector
HDUM1	I*2	Spare
SARA(32)	R*4	Spin axis right ascension (radians; 1950)
SADEC(32)	R*4	Spin axis declination (radians; 1950)
YARA(32)	R*4	Y axis right ascension (radians; 1950)
YADEC(32)	R*4	Y axis declination (radians; 1950)
ESCAN(32)	R*4	Scan angles based on nominal spin axis and true y-axis
IHOUS(10,6)	I*4	Housekeeping scalers (10 scalers, 6 detectors)

Variables	Type	Description
HDISC(8,8,4)	I*2	Discovery scalers (eight 5.12 second sums, 8 scalers, detectors 3-6)
HPLSB(128,3,4)	I*2	PHA 10.24 second readouts (128 channels, 3 10.24 second LSBs, detectors 3-6) for data formats ROM1, RAM9, RAM10. However, there are no 10.24 second LSB readouts for the HED2 detector when in data format RAM10. This array will be zero when in data formats ROM2 and RAM1 - 8.
HPSUM(128,4)	I*2	PHA 40.96 second readouts (128 channels, detectors 3 - 6) as follows: ROM1, RAM9, RAM 10: 40.96 second sums (only 40.96 second LSBs for HED2 in RAM10) ROM2: Array will be zero; there are no PHA data when in ROM2. RAM1 - 8: 40.96 second LSBs

NOTE: The criteria for setting the values of HECON, HCL, HSUPCL, HSFOV, HEAR1, HEAR2, HPT, HDIG, and ESCAN(32) are discussed in Appendices A and B.

Total Length: 5952 bytes

CATALOG DESCRIPTION

A catalog is kept for the production PHA tapes storing the tape number, file number, day, and time range of the data.

The catalog can be accessed from TSO by issuing the following command:

```
QED 'ZBDAL.HEAOTAPE.CATALOG(SKYMAP)'
```

A listing of the catalog can be obtained by using the following JCL:

```
// EXEC LISTPDS,OUT=A,PARM=NOTRUNC
//SYSLIB DD DISP=SHR,DSN=ZBDAL.HEAOTAPE.CATALOG
//SYSIN DD *
SKYMAP
/*
```

PARM=NOTRUNC is needed because the file has a logical record length of 132 bytes, and LISTPDS defaults to printing only 80 bytes.

APPENDIX D - XRATES DATA BASE

INTRODUCTION

The XRATES data base is a condensed version of the MAX data base containing mainly discovery scaler data. Only major frames from MAX that are not in engineering format are included. Each XRATES physical record contains data that was accumulated in one major frame (40.96 seconds) except the digital status which completes a cycle in two major frames, and the analog status which completes a cycle in eight major frames.

TAPE CHARACTERISTICS

TAPE ATTRIBUTES:

9-track, 1600 bpi when produced by program SKYMAP. IBM S/360 system procedure TAPESCAN is then used to condense the XRATES tapes to 6250 bpi.

FILE STRUCTURE:

Each production XRATES file corresponds to approximately 12 hours of data. If no acceptable data exists for a 12-hour interval, no XRATES file exists for the interval. Each tape contains no more than 40 files.

RECORD FORMAT:

Fixed length, blocked.
RECFM=FB,LRECL=5048,BLKSIZE=5048

DATA QUALITY

There are three checks made on the quality of data. A block encoder error indicates a transmission error from s/c to ground. A bit error indicates that 1 or more bits within a minor frame have been improperly received. Fill data indicates that data for that minor frame is missing. An overall data quality flag (HQUAL) is set to indicate if there were any block encoder errors, bit errors, or fill data anywhere in a major frame. Additionally, the data itself is made negative is there were bit errors, and the data is replaced with hexadecimal "AAAA" if there was fill data.

COMMON BLOCK DESCRIPTION

The COMMON Block TAPOUT can be used to reference the XRATES data base. A description of the variables follows:

Variable	Type	Description
LDAY	I*4	Day of major frame
LMSEC	I*4	Millisecond of major frame
HECON	I*2	Electron contamination flag 2**1, 2**0 = LED1 limit=600 2**3, 2**2 = LED2 limit=600 2**5, 2**4 = HED1 limit=1000 2**7, 2**6 = HED2 limit=700 2**9, 2**8 = MED limit=1200 2**11, 2**10 = HED3 limit=500 2**12 = MED superclean limit=600 bits=00=electron rate .le. limit bits=11=electron rate .gt. limit
HVF	I*2	High voltage flag 2**0 = LED1 2**1 = LED2 2**2 = HED1 2**3 = HED2 2**4 = MED 2**5 = HED3 bit=0=high voltage on and not within two frames of turn on bit=1=high voltage off or within two frames of turn on

Variable	Type	Description
HSPAX	I*2	Spin axis index (1-720) Spin circle is divided into 720 half-degree bins
HFRM	I*2	Data format index If in ROM, = ROM number If in RAM, = RAM number +10
HMF	I*2	Major frame counter
HQUAL	I*2	Overall data quality flag 2**0 = block encoder error 2**1 = bit error 2**2 = fill data bit=0=no error bit=1=error NOTE: HQUAL= -4 when there is a gap in time between the present record and the next record.
HCL	I*2	Clean flag 2**0 = LED1 2**1 = LED2 etc. bit=0=not clean bit=1=clean
HSUPCL	I*2	Superclean flag 2**0 = LED1 2**1 = LED2 etc. bit=0=not superclean bit=1=superclean

Variable	Type	Description
HVANOM	I*2	High voltage anomaly flag 2**0 = LED1 2**1 = LED2 etc. bit=0=stable bit=1=unstable
HASUN	I*2	SAA/NPA anomaly flag - also sunlight flag 2**0 = SAA/NPA bit=0=no SAA/NPA bit=1=SAA/NPA 2**1 = sunlight bit=0=no sunlight bit=1=sunlight
HJET	I*2	Number of jet firings during major frame
HSFOV	I*2	Source in field-of-view flag 2**0 = LED1 2**1 = LED2 etc. bit=0=no source in large field-of-view bit=1=source in large field-of-view 2**8 = LED1 2**9 = LED2 etc.

Variable	Type	Description
		bit=0=no source in small field-of-view bit=1=source in small field-of-view
THETA	R*4	Rotation angle from S/C y-axis about S/C z-axis to center of Earth ($-\pi$ to $+\pi$)
PHI	R*4	Angle from S/C z-axis to center of Earth (0 to π) NOTE: Together THETA and PHI define a vector from S/C to center of Earth in S/C coordinates.
HEAR1	I*2	Earth occultation flag (including 200 km atmosphere) 2**0 = LED1 2**1 = LED2 etc. bit=0=no occultation bit=1=occultation
HEAR2	I*2	Earth occultation flag (including 100 km atmosphere) 2**0 = LED1 2**1 = LED2 etc. bit=0=no occultation bit=1=occultation

Variable	Type	Description
HPT	I*2	Spin axis flag 2**0 bit = 0 spin period nominal = 1 spin period not nominal 2**1 bit = 0 spin axis is within 2° of Sun = 1 spin axis is not within 2° of Sun
HDIG	I*2	Digital status flag 2**1, 2**0 = LED1 2**3, 2**2 = LED2 etc. where the two bits per detector represent LSB - DPU status MSB - digital status bit=0=no change bit=1=changing
STIME	R*4	Solar time (radians)
GLON	R*4	Geodetic longitude of s/c (rad)
GLAT	R*4	Geodetic latitude of s/c (rad)
ECNTR	R*4	Distance from s/c to Earth center (km)
AMACL	R*4	McIllwain L parameter
XB	R*4	x, y, z components of magnetic field in s/c coordinates
YB	R*4	
ZB	R*4	

Variable	Type	Description
XM	R*4	x, y, z components of Moon position in s/c coordinates (is the vector from spacecraft to Moon)
YM	R*4	
ZM	R*4	
IDUM2	I*4	Spare
QSTATE(25)	L*1	Experiment status words
QSTATD(13,6)	L*1	Digital status words for six detectors
QDUM1	L*1	Spare
QSTATA(32,8)	L*1	Analog status words (32 words per major frame; 8 major frames to complete a cycle.)
SARA(32)	R*4	Spin axis right ascension (radians; 1950)
SADEC(32)	R*4	Spin axis declination (radians; 1950)
YARA(32)	R*4	Y axis right ascension (radians; 1950)
YADEC(32)	R*4	Y axis declination (radians; 1950)
IHOUS(10,6)	I*4	Housekeeping scalers (10 scalers, 6 detectors)
HDISC(40,8,6)	I*2	Discovery scalers (40 LSBs and sums; i.e., 8 readouts per major frame of 5 discovery scalers: four 1.28-seconds one 5.12-seconds 8 scalers, 6 detectors)

NOTE: The criteria for setting the values of HECON, HCL, HSUPCL, HSFOV, HEAR1, HEAR2, HPT, and HDIG are discussed in Appendix A.

Total Length: 5048 bytes

CATALOG DESCRIPTION

A catalog is kept for the production XRATES tapes storing the tape number, file number, day and time range of the data.

The catalog can be accessed from TSO by issuing the following command:

```
QED 'ZBDAL.HEAOTAPE.CATALOG(SKYMAP)'
```

A listing of the catalog can be obtained by using the following JCL:

```
// EXEC LISTPDS,OUT=A,PARM=NOTRUNC
//SYSLIB DD DISP=SHR,DSN=ZBDAL.HEAOTAPE.CATALOG
//SYSIN DD *
SKYMAP
/*
```

PARM=NOTRUNC is needed because the file has a logical record length of 132 bytes, and LISTPDS defaults to printing only 80 bytes.

APPENDIX E - MAP DATA BASE

INTRODUCTION

The MAP data base is a cumulate data base using the Discovery Scaler rates for the HED and MED detectors. Each data tape consists of a multiple file volume containing data for about 240 days. Each file contains 12 hours of data, placed in nine records. The first record is a header record which contains bin locations in Celestial 1950, ecliptic, and galactic coordinates. For each detector there are two data records, one for clean, unocculted data, and one for superclean, source-free data.

Data is binned by 0.25° in ecliptic latitude, and 12-hour, i.e., 0.5° in ecliptic longitude. Each data point, a 1.28-second accumulation corresponding to about 0.25° of scan, is placed in the bin corresponding to the center of the accumulation. A major frame must be in scan mode, have a ROM1, ROM2, RAM1, RAM9, or RAM10 memory format, and have a McIllwain L-value less than 1.2 in order for its data to be considered for accumulation for the MAP tape. The data for each detector is accumulated if it is free of electron contamination, has clean status and constant DPU and digital status, is unocculted by the Earth plus 200 km atmosphere, and has a nominal status. For accumulation as superclean data, each detector must be accumulated as clean, with the additional criteria that the detector have super-clean status for the major frame, and no sources in its large field-of-view. For the MED detector, there is also the requirement that it be free of electron contamination when using the superclean rate limit of 600.

DATA BASE CHARACTERISTICS

TAPE ATTRIBUTES:

9-track, 1600 bpi when produced by program SKYMAP. IBM S/360 system procedure TAPESCAN is then used to condense the MAP tapes to 6250 bpi.

FILE STRUCTURE:

Each production MAP file corresponds to approximately 12 hours of data. If no acceptable data exists for a 12-hour interval, a MAP file with zeros stored in the data arrays is output.

RECORD FORMAT:

Fixed length, blocked.
RECFM=FB,LRECL=25968,BLKSIZE=25968

RECORD TYPES

There are always nine MAP records per file. All nine records have a 48-byte header which contains two identifying variables: record type (ITYPR) and clean type (ITYPC). These two variables allow selection of data by detector and clean-superclean.

Record Number	Record Type	Clean Type
1 (general data)	0	0
2 (det. 3 clean)	3	1
3 (det. 3 superclean)	3	2
4 (det. 4 clean)	4	1
5 (det. 4 superclean)	4	2
6 (det. 5 clean)	5	1
7 (det. 5 superclean)	5	2
8 (det. 6 clean)	6	1
9 (det. 6 superclean)	6	2

Where Record type 0 - data for all detectors
Record type 3-6 - data for detectors 3-6 (i.e., HED1, HED2, MED, and HED3, respectively.)

Clean type 0 - not applicable

Clean type 1 - clean data

Clean type 2 - superclean data

RECORD DESCRIPTION

The COMMON block MAPOUT can be used to reference the MAP data base. A description of the variables follows:

** BEGIN HEADER FOR EACH RECORD **

ISDAY	I*4	Start day of file
ISMSEC	I*4	Start millisecs. of file
IEDAY	I*4	End day of file
IEMSEC	I*4	End millisecs. of file
ITYPR	I*4	Record type 0, 3-6
ITYPC	I*4	Clean type 0-2
IFILE	I*4	PHA tape file number corresponding to this MAP data. 0 = no PHA file exists.
ISPIN	I*4	Spin axis index (1-720) Spin circle is divided into 720 half-degree bins
RASPIN	R*4	Nominal spin axis right ascension in 1950 coordinates (radians)
ADSPIN	R*4	Nominal spin axis declination (rad.) 1950 coordinates
ISPAR1	I*4	Spare
ISPAR2	I*4	Spare

** END OF HEADER **

FOR RECORD TYPES 3-6, the data starting in word 13 are

HDSUM(1440,8)	I*2	1.28 second Discovery scaler accumulations for 1440 1/4° scan angles and 8 scalers.
HEXP(1440)	I*2	Exposure matrix for the discovery scalers in HDSUM

FOR RECORD TYPE 0, the data starting in word 13 are

ESANG(1440)	R*4	Ecliptic scan angles 0 - 360° in 0.25° bins (radians)
GALON(1440)	R*4	Galactic longitude corresponding to scan angles 0° - 360°
GALAT(1440)	R*4	Galactic latitude corresponding to scan angles 0° - 360°
IFILL(2160)	I*4	Spare.

Common block MAPOUT may be used to access any MAP tape record.

```
    COMMON /MAPOUT/  ISDAY, ISMSEC, IEDAY, IEMSEC, ITYPR,
*   ITYPC, IFILE, ISPIN, RASPIN, ADSPIN, ISPAR1, ISPAR2,
*   HDSUM (1440, 8), HEXP (1440)
```

For record type zero, equivalence ESANG(1) to HDSUM(1,1).

CATALOG DESCRIPTION

A catalog is kept for the production MAP tapes storing the tape number, file number, orbit, and time range of the data.

The catalog can be accessed from TSO by issuing the following command:

```
QED 'ZBDAL.HEAOTAPE.CATALOG(SKYMAP)'
```

A listing of the catalog can be obtained by using the following JCL:

```
// EXEC LISTPDS,OUT=A,PARM=NOTRUNC
//SYSLIB DD DISP=SHR,DSN=ZBDAL.HEAOTAPE.CATALOG
//SYSIN DD *
SKYMAP
/*
```

PARM=NOTRUNC is needed because the file has a logical record length of 132 bytes, and LISTPDS defaults to printing only 80 bytes.

CSC

COMPUTER SCIENCES CORPORATION

Major Offices and Facilities Throughout the World

HEAO-1

A-2 SORTED FCUT SOURCE DB

77-075A-02P

This data set consists of 5 tapes. The tapes are multifiled, 9-track, 1600 BPI, binary, and were created on a IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101450	C-032304	83	01/01/77 - 03/31/77
D-101451	C-032305	74	04/01/77 - 06/29/77
D-101452	C-032306	74	06/30/77 - 09/27/77
D-101453	C-032307	89	09/28/77 - 12/26/77
D-100454	C-032308	42	12/27/77 - 02/19/78

77-075A-02P

CSC/TM-81/6116

HIGH ENERGY ASTRONOMY OBSERVATORY-A2 FCUT SOURCE ANALYSIS PROGRAM (FCUT-A) PROGRAM DESCRIPTION USER'S AND OPERATOR'S GUIDE

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-24350
Task Assignment 606

MAY 1981

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-81/6116

HIGH ENERGY ASTRONOMY OBSERVATORY-A2
FCUT SOURCE ANALYSIS PROGRAM (FCUT-A) PROGRAM DESCRIPTION
USER'S AND OPERATOR'S GUIDE

Prepared by

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-24350
Task Assignment 606

Prepared by:

A R Stottlemyer 12 May 81
A. Stottlemyer Date
Section Manager

Approved by:

Richard F. Williams 5/12/81
R. Williams Date
Department Manager

TABLE OF CONTENTS

ABSTRACT

The Cosmic X-ray Experiment (A2) on board the first High Energy Astronomy Observatory (HEAO-1) is designed to survey the emission of non-solar X-rays over the entire sky. The HEAO-A2 data processing system provides computerized analysis and bulk data processing for this experiment at Goddard Space Flight Center (GSFC). The First Cut Source Analysis Program (FCUT-A) provides a preliminary analysis of the observed X-ray intensities of a catalogued list of about 400 X-ray sources. This document, as supplemented by in-code documentation, provides a complete program description, operator's guide and user's guide. The program was coded in FORTRAN for use on the Science and Applications Computer Center (SACC) IBM 360 computers at GSFC.

SECTION 1 - INTRODUCTION

The first High Energy Astronomy Observatory (HEAO-1) satellite was launched in August 1977 with the mission of surveying the full sky for non-solar X-ray emission over a wide range of X-ray energies. The A-2 experiment consists of six detectors which, between them, cover a range in X-ray energy from 0.25 KeV to 60 KeV, and is designed to provide systematics free energy spectrum data for point and extended sources of X-rays. The experiment is mounted so as to observe the sky in a direction perpendicular to the satellite spin axis. With this orientation, each detector scans a 3-degree wide great circle of the sky each thirty minutes, and, as the spin axis precesses to point at the sun, observes the full sky over a period of 6 months.

The six detectors consist of two Low Energy Detectors (LEDs), one Medium Energy Detector (MED), and three High Energy Detectors (HEDs). Each detector observes two co-axial fields of view separately, one collimated to 3° by 3° (FWHM) and the other either 3° by $1\ 1/2^{\circ}$ or 3° by 6°. Each field of view is observed by a multi-wire gas proportional chamber with separate outputs for each field of view in two layers of anodes, and also for exterior layers of anodes which are used to discriminate against charged particles. The data output from each detector consists of the following types: engineering analog parameters (analog status), digital experiment parameters (digital status), raw anode couting rates (Housekeeping scalers), standard coincidence counting rates (Discovery scalers), pulse height analyzed rates (PHA histograms), calibration pulse height analyzed events (Calibration data), and a type with a variety of counting rate versus time output modes (Delta-t computer).

The First Cut Analysis Program (FCUT) was designed to provide preliminary analysis of the scanning data in a variety of areas of general interest. These areas include detector calibration, analysis of the unresolved X-ray background, analysis of the non-X-ray background, and point source analysis. For operational reasons, the point source analysis portion reached final development as a separate version of the basic program. It is this version which is described in this document.

The FCUT source analysis uses the data from the HED and MED detectors, specifically the Discovery Scalers and the 80 millisecond multiscaler mode of the Delta-t computer, to determine the X-ray emission as a function of time for all X-ray sources in the HEAO-A2 source catalogue. The program is written in FORTRAN for use on the IBM 360 computers at GSFC. It uses the primary HEAO-A2 data base, MAX, as input and produces output in the form of printout, microfilm, and summary magnetic tapes.

SECTION 2 - OVERVIEW

2.1 SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules to perform separate tasks for quality control, establishing data bases for more convenient and efficient analysis, and performing some preliminary analysis of the data. The system is designed to perform both as "Quicklook", almost real-time, processor and as an off-line "Production" data analysis system. The system design incorporates the ability to perform both of these functions in parallel, and also to process large quantities of data in parallel. Figure 2-1 illustrates the designed system flow. This entire system is designed for operation of the SACC IBM 360-75 and 360-91 computers at GSFC.

The data input to the system is received from GSFC's Information Processing Division on magnetic tape in a format defined by NASA document "HEAO-A Data Processing Requirements Document."[1] Quicklook and Production data both have the same data and file format, differing only in the accuracy of the satellite attitude and orbit parameters. Quicklook data is normally produced for one orbit perday, and is available within 8 hours of transmission, while Production data is produced for all telemetry, and is available within 6 weeks of transmission. The X-ray Source Catalog was compiled by the A2 experimenters, and incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disk file on a PDP-11/70 in the Laboratory for High Energy Astrophysics at GSFC, with a subsidiary version maintained on disk on the SACC computers.

[1]National Aeronatuics and Space Administration, GSFC, X-565-77-60, Data Processing Requirements for High-Energy Astronomy Observatory A (HEAO-A), H. Linder, June 1977.

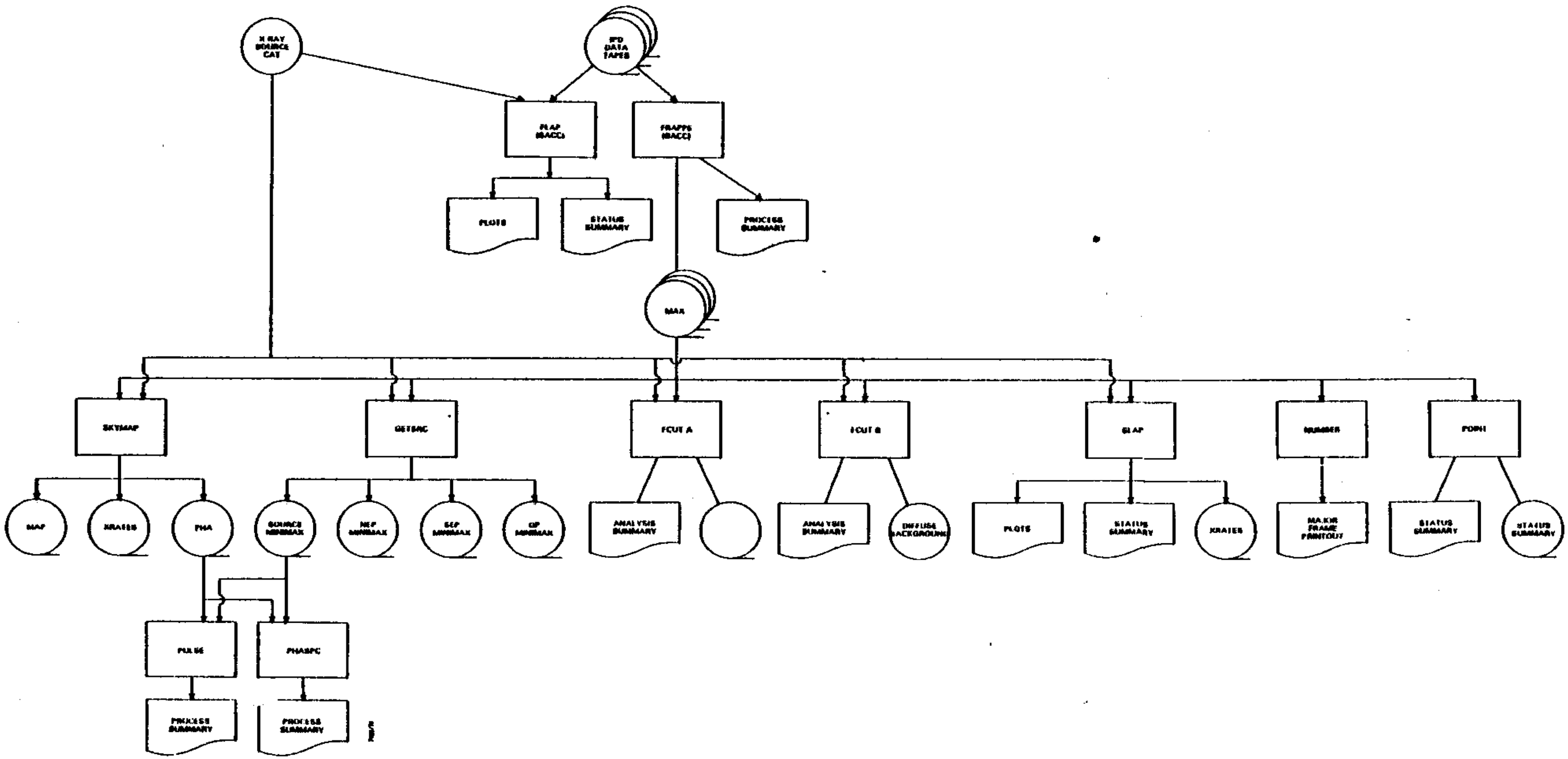


Figure 2-1

The first processing of received data performs a series of detailed tests to evaluate data quality and experiment health and status, and also displays some of the raw data in a way which allows some very preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

The next stage of data processing is the production of a restructured data base (MAX), which serves to ease the data analysis. This is done by re-formatting the data into a FORTRAN-accessible format, re-ordering the data from telemetry stream order to accumulation time order, and by setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Re-blocking and Production Processing Executive (FRAPPE) is the program which reads an IPD format tape and produces the MAX data base. The file structure of the MAX data base is centered on the changes in the spin axis position which occur approximately every 12 hours.

A series of modules have been set up which use the MAX data base as input, and which perform preliminary analysis function and also produce several condensed data bases.

The first of these modules is the Second Look Analysis Program (SLAP). This program generates a complete, detailed experiment status report, a complete set of detector counting rate plots, and optionally a condensed data base (XRATES) of selected detector rates. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest. This program is used to process only selected production data for diagnostic purposes.

A second module is designed to produce a very detailed output from analysis of limited segments of data. This module, program NUMBER, examines the data on a Major Frame basis, and generates line printer output for a selected list of data including scaler counting rates, pulse height analysis, and temporal data. Full output for a Major Frame is approximately six pages long, and includes raw data and output from data analysis.

Another module is devoted to routine analysis of Production data. This program (FCUT) calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, performs a parameterization of the non-X-ray background, searches for new point sources, and performs a detailed analysis of the rates of known X-ray sources, forming a data base of the known source results.

Two more modules serve to create condensed data bases from the Production MAX data base. The first, program GETSRC, extracts Major Frame records from the MAX data base whenever a selected location of the sky is being observed, and places these records in time order on a separate output tape (MINIMAX). This program will be used to routinely create tapes for the data for the North Ecliptic Pole, South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations will be created upon request using this program. The second module, program SKYMAP, normally creates three specialized data bases. The first of these data bases, MAP, contains Discovery scaler data, averaged over time, which is ordered by the observed location of the sky. The second data base, PHA, contains PHA data for Major Frames with good data, while the third, XRATES, contains limited rates data for Major Frames with good data. A detailed analysis program will generally use the specialized data bases as input. The specialized data bases are designed to improve the efficiency of detailed analysis by excluding bad data, and by minimizing the amount of memory space devoted to data not wanted for a particular analysis.

2.2 PROGRAM OVERVIEW

Program FCUT was designed for preliminary analysis of several types. The software consists of the general structure for using MAX data with branches out of the major frame processing for each of the types of analysis requested. Because of the size of the resulting program, and also because of delays in defining some of the types of analysis, FCUT was prepared in two parts, the first for analysis of X-ray sources, and the second for all the other analyses. In the version discussed here, the source analysis part, the branches for other analysis were replaced with dummy stubs while retaining the same overall structure.

The source analysis is of three basic types, first a search for new sources, second a rather complex analysis of the known sources, and third a general test for the time variability. The first two types of analysis operate on mutually exclusive sets of the data. Portions of the scanned great circle are defined as source regions containing known sources. The data in the remaining portions of the scan circle are analyzed by the new source methods. All data used for either of these analyses are also examined for temporal variability.

The data used for this analysis are taken from the standard MAX data base. For each major frame, each detector is separately checked for CLEAN data, where this is defined to mean that for that detector, for that major frame:

1. The detector is not occulted by the Earth, including 100 kilometers of atmosphere.

2. The detector voltage is on.

3. The detector high voltage is on and stable.

4. The data is not electron contaminated.

5. The detector DPU is in a normal state, including checks on discovery scaler window definitions and accumulation times.

6. The memory format is acceptable, excluding only the so-called radical RAM's (RAM number > 10).

These tests and all analysis are performed only for four of the six detectors, specifically the Medium Energy Detector (MED), and the three High Energy Detectors (HED). The primary data used for analysis are the Discovery Scaler rates and the 80-millisecond multiscaler rates when available. In addition the list of sources comprising the HEAO-A2 catalog is used to define the locations of known X-ray sources. This catalog was updated as new sources were discovered, and as previously claimed sources were not observed. The output data consist of a detailed printout of all results, described in Section 3, and a magnetic tape containing the fitted source intensities for the known sources on a pass-by-pass and also a 12 hour basis.

2.3 ANALYSIS TECHNIQUES

2.3.1 The Temporal Variability Search

The basic idea is that, when scanning, HED-2 observes the same area of the sky that HED-1 will observe about 30 seconds later. Thus the difference in counting rates between the two detectors for the same spot in the sky can be determined for a time difference of about 30 seconds, and should be a constant unless the emitted rate is varying within that time period. Assumptions included here are that the general environmental factors such as charged particle fluxes do not change significantly in this time period. While generally true, both of these are occasionally violated. The spin axis has been observed to change by as much as one half degree during 40 seconds, which is enough to cause problems if the area observed contains a strong source. In addition, a very strong source may be flagged simply because of the slightly different energy response of the two detectors.

The detector rates with the smallest accumulation time are used so as to match the observed sky positions as closely as possible. This means that the 80-millisecond multiscaler rate is used when present in both detectors, and otherwise the 1.28-second Discovery Scaler rates, summed for the first four scalers, are used. If the Discovery Scalers are being used and overflow, the data are flagged with a warning, and 5.12-second rates are used. For each rate in a major frame of HED-2 data, the HED-1 data point corresponding most closely in scan angle is subtracted to form the difference rates. Using these the chi square is calculated for a constant difference over the major frame. Specifically,

for N = the number of rates in a major frame
$C1_i$ = the i^{th} rate in HED-1, $i = 1,N$
$C2_i$ = the i^{th} rate in HED-2, $i - 1,N$

where $C1_i$ is the rate corresponding most closely to $C2_i$ in scan angle

then
$$\bar{D} = \sum_{i=1}^{N} (C2_i - C1_i) \quad /N$$

$$\overline{C1} = \sum_{i=1}^{N} C1_i \quad /N$$

$$\overline{C2} = \sum_{i=1}^{N} C2_i \;/N$$

and $$\chi^2 = \sum_{i=1}^{N} (C2_i - C1_i - \bar{D}) \;/\; (\overline{C1} + \overline{C2})$$

If the chi square probability for a constant difference is less than one percent, then an autocorrelation function is calculated for the set of rate differences using a standard technique, (see Section 2.3.4.3) and a message is printed giving the time of the HED-2 data, the scan angle for the center of the major frame, the chi square, number of bins, and the results of the auto correlation analysis.

2.3.2 The Definition of Source Regions

Once at the start of each spin axis position, or about each 12 hours, a list is made of the known sources on the permanent catalog within 3 1/2 degrees of the nominal scan plane. The nominal spin axis is defined to be the solar ephemeris at 8 A.M. for the first half of the day, and 8 P.M. for the second half. These sources are then ordered by angle.

A source region is defined as a continuous interval in scan angle containing one or more sources, and bounded by an interval of at least 15 degrees on either side which is free of sources. The size of the source free interval is chosen to be large enough that all detectors will have at least a 3-degree interval in which no sources are in the field of view. Due to the number of sources, if the interval were much larger one would end up with one source region covering over half the scan circle. This would be inadequate for the known source analysis because of expected variations in internal and external backgrounds over that large an interval in time and observed position.

Once the source regions are defined by their boundaries, the source list and region list are reordered, if necessary, so that the first region is the one starting at smallest scan angle, and the first source listed belongs to the first source region. This reordering is necessary if the 360/0 degree scan angle is contained within a source region.

2.3.3 New Source Search

This analysis is applied for each detector for each major frame falling in a source free region as defined above. It is based on the idea that a source free region should give a constant rate count over the 40 seconds of data within a major frame.

The data used is the 5.12 second rate for the sum of the first four Discovery Scalers for each detector. The chi square is calculated assuming a constant rate. If the chi square probability for a constant rate is less than one percent, the time of the data, the detector axis scan angle, and the rates are printed out with a message. It should be noted that at this level of confidence, the test will be failed by one of the four detectors about once each 25 major frames of source free data, but the probability of two detectors in the same frame is only about 0.01 percent, or about once per week of data!

2.3.4 Known Source Analysis

For each pass of the experiment over a defined source region a least squares fit is performed for each detector assuming constant source and background rates during the pass. The results of this fit are the background rates for each field of view and the source rate normalized to the on-axis detector area, along with the respective errors. In addition, a fit to the source region for 12 hours of data is also performed with the same rates as results. The results of the single pass fit are then compared to the data for that pass to check for goodness of fit. If the fit is bad, then it is assumed that either a known source is varying, or there is an undiscovered source present. Analysis by Fast Fourier Transform (FFT) and auto-correlation are used to try to distinguish the source of the variations. The results of such analysis are printed. In addition, at the end of the 12 hour period, the full 12-hour fit is calculated and the result compared to the single pass results to determine if these are consistent with constant source and background rates during the entire 12 hour period. Results for single pass and 12 hour rates are printed, and also written onto magnetic tape.

The general method of performing the least squares fit is described in Appendix D. This is a standard methodology, and can be found in many standard applied mathematics texts. An unweighted least squares fit was used to avoid the complexities and biases of the normal weighting schemes. As a result, source regions with large sources present tend to have larger errors on the background and small source rates. Our particular parameterization follows the general technique for this case.

2.3.4.1 The Least Squares Fit

For the source intensity determination we define a model which assumes constant background rates and constant source rates for the duration of the pass over the defined region. For a given layer of detector it is assumed that the counts arising from a point source are the same in the two fields of view when corrected for the difference in effective areas exposed to the source. It is assumed that the background rates differ in the two fields of view.

This leads to a separate parameterization of the count rate for each pair of Discovery Scalers of the form:

$$N_i = B + \sum_g g_{ij} S_j$$

where N_i is a 1.28 second accumulated rate for the i^{th} time interval.

B is the background rate to be determined.

S_j is the set of on-axis count rates due to the point sources which are found in the defined source region.

g_{ij} is the detector area correction factor applied to rate j for time interval i.

This model, in its simplest form, applies to each Discovery Scaler separately. To model the pair, we formally define the parameterization to be:

$$N_i = \sum_{j=1}^{N_s + 2} g_{ij} I_j$$

where N_s is the number of sources in the fit. The determined I_j now includes the source rates and the background rates, with $I_{N_s + 1}$ the left field of view background and $I_{N_s + 2}$ the right field of view background. The set of N_i now includes both the left and right fields of view rates. The coefficeint g_{ij} now is the formal sum of the left and right coefficients, with the understanding that if the data point is a left field-of-view rate, then all the coefficients of the right side are zero. The coefficients for the background terms are always one or zero. The non-zero coefficients for the source terms are the effective areas exposed to the source for that field of view.

The fit itself is an unweighted least squares fit, i.e. one minimizes

$$S = \sum_{i=1}^{2M} \left(N_i - \sum_{j=1}^{N+2} g_{ij} I_{ij}\right)^2$$

Thus the A matrix of Appendix D becomes

$$\bar{A} = \left[\sum_{i=1}^{2M} g_{ij} g_{ki}\right]$$

with j and k = 1, $N_s + 2$.

The b matrix becomes

$$\bar{b} = \left[\sum_{i=1}^{2M} g_{ik} N_i\right]$$

The matrix solution then is

$$\bar{I} = \bar{A}^{-1} \bar{b}$$

The form of the covariance matrix becomes that of equation D-14, with σ_f^2 being derived from equation D-86. This equation reduces to

$$\sigma_f^2 = \left(\sum_i N_i^2 - 2 \bar{I}^T \bar{b} + \bar{I}^T \bar{A} \bar{I}\right) / \left(2M-N_s-2\right)$$

The variances saved by FCUT are the diagonal terms of this covariance matrix, i.e. the diagonal terms of

$$\sigma_f^2 (\bar{A})^{-1}$$

2.3.4.2 The Detector Exposure Calculation

The calculation of the area of a detector, for a given field of view, observing a particular source is fairly straight forward in principle. Since the collimators are rectangular, we defina a coordinate system with the Z axis, usually called simply "the detector axis", parallel to the intersection collimator walls, and the X and Y axes parallel to each of the two sidewalls. Define angles θ and ϕ such that θ represents a rotation about the detector X axis and ϕ a rotation about the detector Y axis, with zero being the direction along the Z, or collimator, axis for both angles. Further define θ_D and ϕ_D to be the collimator opening angles, i.e. the maximum angle away from the Z axis with any area exposed. Then the fraction of the detector field of view exposes to a point located at (θ,ϕ) is given by:

$$(1 - 1 \tan \theta/\tan \theta_D) \cdot (1 - 1 \tan \phi/\tan \phi_D)$$

if θ is less than θ_D and ϕ is less than ϕ_D, with zero exposure otherwise.

For the case of a source being observed, the position is not constant in time, and may vary considerably over the time during in which data is being accumulated. Since the observed rate varies with the exposed area, a determination of the average exposure is sufficient. Since only data in scan mode is being used, and since the scan rate is about 0.2 degrees per second, it was assumed that, for the 1.28 seconds which is the longest data accumulation time, the motion of a source in detector coordinates is approximately constant. Thus the average exposure was calculated using the approximation that

$$\frac{d(\tan\theta)}{dt} \quad \text{and} \quad \frac{d(\tan\phi)}{dt}$$

were constant over the accumulation. For accumulations of less than one minor frame (0.32 seconds), it was further assumed that the exposure at the center of the accumulation was a good estimate of the average. For accumulations longer than one minor frame, the exposure area was integrated over the time and the average taken. The integration method used assumes that there is at most one discontinuity in

$\partial f/\partial(\tan\theta)$ during the accumulation, which will be in error for the MED and HED3 if the rotation is over 1 1/2 degrees during the accumulation, or a rotation period of less than about 20 minutes for the 5.12 second rates.

2.3.4.3 Analysis of the Source Fit

Analysis of the results of the fit starts with a comparison of the single pass region fit to the data for that pass. For this comparison, the 80-millisecond multiscaler data is used if available, and the 1.28 second rate for the sum of the first four Discovery Scalers (both fields of view, both layers) is used otherwise. If the 1.28 second data overflows, the overflow is approtioned in the shape of the fit. The basic comparison is in the form of a calculated chi square for each data point against the rate expected from the fit. For purposes of a more detailed study, the region is divided into three types of data zones: background zones where no source is observed for each data point, source zones where the fitted rate for a single source comprises at least half the total rate, and mixed source zones where there is no strong source dominating the rate.

For each data point, the chi square of fitted rate to data is calculated assuming a Poisson error about the fitted rate. For each zone, and for the total region, the chi square and probability of fit are calculated. If the probability of fit is less than 2 percent for any zone, a message results. The data of any source zone with such a bad fit is then subjected to analysis for temporal variations. All data for source zones is used to calculate a normalized variance for each source with a rate larger than about 5 UHURU counts per second, i.e. bright enough to form a source zone. This variance is normalized to the expected Poisson variance as described in Appendix E.

The temporal analysis for each source with a bad fit to a constant rate consists of an auto-correlation analysis, and if multiscaler data is present, a Fast Fourier Transform (FFT) analysis. The results of the auto-correlation of 2N points equally spaced in time is R_j, the set of N terms where

$$R_j = \sum_{i=1}^{2N-j+1} (y_i - \langle y \rangle)\ (y_{i+j} - \langle y \rangle) \ / \ (\sigma_{yi}\ \sigma_{yi+j})$$

with $\langle y \rangle = \left(\sum_{i=1}^{2N} y_i/\sigma_{yi}^{2}\right) \ / \ \left(\sum_{i=1}^{2N} \sigma_{yi}^{-2}\right)$

and $j = 1,N.$

In FCUT, if the number of rates is odd the last point is not used. The rate used for the auto-correlation is the data with the fitted rate for background and other sources subtracted, normalized to be equivalent to the full detector exposure, i.e.

$$y_i = (m_i - b_i - \sum_{k=1}^{is} s_{ik}) \ / \ f_i \ , \text{ where}$$

m_i = actual rate for this point

b_i = fitted background rate

s_{ik}= fitted rate for other sources for this point

f_i = fraction of detector area exposed to primary source for this data point

The error used is calculated assuming independence of the parameters:

$$\sigma_{yi}^2 = (m_i + \sigma_b^2 + \sum_{k=1}^{is} \sigma_{ik}^2) \;/\; f_i^2$$

The FFT analysis was a standard method except that the set of data points (y), is expanded to the next larger power of 2 by filling in the dummy points with the average of the real data. This affects only the coefficient corresponding to the duration of the full data set. A detailed description of the technique can be found in published books.[2] The results are printed in the form of frequency power and approximate probability for chance occurance. The power for a given term is the square of its absolute value divided by the average for all terms, with a correction for base-line shifts. Specifically, for the set of complex amplitudes Ci,

for $$\bar{x} = \sum_i \left[\mathrm{Re}\;(Ci) + \mathrm{Imag}\;(Ci)\right] \;/\; (N-1)$$

and $$\mathrm{var} = \sum_i |C_i|^2/\;(N-1) \;-\bar{x}^2$$

then the define power, P, is

$$P_i = |C_i|^2/\mathrm{var} \quad ,$$

and the approximate chance probability is just

$$\mathrm{Prob}_i = e^{-Pi}$$

2 N. Ahmad and K. Rao, "Orthogonal Transforms for Digital Signal Processing", Springer-Ver(ag, 1975)

2.3.4.4 Twelve Hour Source Analysis

The fit matrix elements for each pass over a given source region are saved and added together to form the basis of a 12 hour least squares fit. This implicitly assumes constant source rates and background for the 12 hours as a model. The duration of 12 hours was chosen simply because it is the longest period during which the spin axis is nominally constant. In addition to the overall 12 hour fit, the source and background results from each pass are saved for this period so as to allow comparison with the overall fit.

For each source and background, a chi square is calculated for each of the scaler rates with the model being that the source rate is constant and equal to the 12 hour fit rate. This is only an approximate chi square in that the error used in the calculation is that of the single pass result. For the background rates, each of the Discovery Scaler rates is separately checked, with an instability flag set if the chi square probability is less than 1 percent, and additional flags are set for left field-of-view (FOV), right FOV, and internal and diffuse background rates using the sum of the chi squares calculated for the first two scaler pairs with the flags set if the probability is less than 1 percent. For each source, the sum of the chi squares for the first two scaler pairs is calculated, the instability flag set if the chi square probability is less than 1 percent.

For each source strong enough to create a source zone in the single pass analysis, a normalized on-axis variance is calculated based on ideas of Dr. E. H. Boldt of GSFC (see Appendix E). Specifically, for each pass with a source zone, two terms are accumulated for the source,

$$V_p = \chi_y^2 - \mathrm{NDOF}$$

$$U_p = \sum_{i=1}^{Ns} [f_i / (1 + B_p/f_i)]$$

where χ^2 is the chi square for the zone fit

NDOF is the number of degrees of freedom

N_p is the total number of data points in the zone

f_i is the fraction of the total detector area exposed to the source for each point (left and right)

B_p is the ratio of the fitted background rates, left plus right FOV, to 2 times the on-axis source rate, with the factor of two representing left plus right FOV.

Then when these have been accumulated for each pass during the 12 hours, the final variance is given by,

$$VAR = 1 + \sum_p V_p \;/\; \sum_p U_p \quad .$$

The final form of 12 hour analysis is a tabulation of standard hardness ratios for each source, based on the results of the 12 hour fit. The 7 defined and calculated ratios are:

$$R1 = MED(4) \;/\; [MED(2) - MED(4)]$$
$$R2 = MED(1) \;/\; [MED(2) - MED(4)]$$
$$R3 = MED(4) \;/\; MED(1)$$
$$R4 = MED(3) \;/\; MED(4)$$
$$R5 = HED(2) \;/\; HED(1)$$
$$R6 = HED(4) \;/\; HED(2)$$
$$R7 = HED(3) \;/\; HED(1)$$

where MED(i) is the fitted source rate in the i^{th} MED Discovery Scaler pair, and the ratios R5, R6, and R7 are separately calculated for each HED. Errors are calculated assuming statistical independence of the rates.

2.4 Software Overview

This section consists of a high level description of the software elements which make up the source analysis version of FCUT. It is comprised of a functional overview relating the software elements to the program functions, and a software structure segment describing the inter-relationships of these software elements. The software description is supplemented by the data format descriptions in the Appendices and the program FRAPPE document, and by the in-code documentation. The source code is located in two partitioned data sets, ZBARS.FCUT.SOURCE and ZBARS.FCUT.SOURCE2, maintained on the SACC system.

2.4.1 Functional Structure

Table 2-1, Module Descriptions, contains the functional description of all models within the program. In order to clarify the functional relationships we will discuss the software substructures with the program in terms of the jobs performed.

Table 2-1

MODULES DESCRIPTIONS

1.	ANLREG	-	Control routine for the modeling of single-pass data using known x-ray sources and background.
2.	AUTOC	-	Calculates the auto correlation function. Used to analyze 80-millisecond rate data for sources thought to be time-variant.
3.	CLEAN	-	Calculates the primary data quality flag for each major frame record.
4.	CONVEC	-	A utility routine which transform a 3-vector under rotation.
5.	CROSS	-	A utility routine which calculates the 3-vector cross product.
6.	CVXYZ	-	A utility routine which calculates the 3-dimensional unit vector corresponding to a direction given by Right Ascension and Declination.
7.	DCOVUP	-	Re-orders a matrix with zero determinant to form the largest possible non-singular matrix. Used with DSYMIN to avoid problems inverting matrices with zero's in a row or column.
8.	DEFREG	-	Defines the regions of the experiment scan path to be used as units for a least squares fit modeled on known, constant sources and background.
9.	DIGIT	-	Calculates a flag indicating that the experiment status does not change within a given major frame of data.
10.	DOT	-	A utility routine which calculates the 3-vector scaler product.

11.	DREAD	-	A SACC system utility for reading as direct access file.
12.	DSLOAD	-	Calculates the elements of the matrices used to fit to the model of known sources and background.
13.	DSYMIN	-	Calculates the inverse of a symmetric matrix.
14.	DWRITE	-	A SACC sytem utility for writing into a direct access file.
15.	ECONFC	-	Determines if data for a given major frame is electron contaminated.
16.	EFFDET	-	Determines the average detector area exposed to a source during a rate accumulation in scan mode.
17.	EOCC	-	Determines if a detector observes a sphere 200 kilometers larger than the earth during a major frame.
18.	EPHEM	-	Initiates the calculation of the solar ephemeris corresponding to a given time.
19.	ESRCES	-	Selects the list of x-ray sources from the catalog which are expected to be observed during a 12-hour period.
20.	FFT	-	Calculates a Fast Fourier Transform. Used with 80-millisecond rate data for sources thought to be time variant.
21.	FINALF	-	Controls the analysis performed at the end of a 12 hour period of data.
22.	FITREG	-	Controls the least squares fit for single pass data to the model of known sources and background.

23.	FOVIEW	-	Determines if any portion of an angular cone of the sky is in the field of view of a detector given the spacecraft attitude.
24.	FREAD	-	A SACC system utility for reading magnetic tape files.
25.	FWRITE	-	A SACC system utility for writing magnetic tape files.
26.	HEADER	-	This prints file header information for a MAX file.
27.	INIT	-	This reads program control data and initializes those variables to be set at execution time.
28.	INIT2	-	This initializes the direct access scratch file used to store single-pass analysis results.
29.	JDAY	-	This calculates the Julian day number corresponding to the day of 1977 standard used for HEAO-A2 data.
30.	KTM	-	A SACC system utility which performs logical bit tests.
31.	MAIN (FCUT)	-	The entry routine for the program. It controls the logical flow for processing MAX data files.
32.	MATFIT	-	Calculates the solution and variance vectors for the least squares fit to the model of known sources and background.
33.	MDCDFI	-	A SACC system utility which calculates the probability of exceeding chi-square for a given number of degrees of freedom.
34.	MFOV	-	Determines if the moon is in the field of view of any detector during a major frame.

Table 2-1 (Continued)

35.	MOUNT	-	A SACC system utility for mounting magnetic tapes.
36.	NEWSRC	-	This tests all data with no known x-ray sources present for constant rate, as a search for new sources.
37.	NOMINL	-	This compares current experiment status against the nominal state for a given format and flags data which varies in any way.
38.	POSN	-	A SACC system utility to position magnetic tapes to a given file.
39.	PROG1	-	Performs the initilization required at the start of a file of data, and checks remaining run time. This routine can force termination of the job.
40.	PROG2	-	Controls data analysis of a major frame block.
41.	REMTIM	-	A SACC system utility which returns the remaining CPU and IO time during program execution.
42.	REWIND	-	A SACC system utility which rewinds a magnetic tape.
43.	SCANGL	-	Calculates the ecliptic scan angle corresponding to the given spacecraft coordinate axis vectors.
44.	SPFLAG	-	Checks that the spacecraft is operating in normal scan mode by testing spin rate and spin axis direction.
45.	SRCANL	-	Controls the analysis of a major frame of data for x-ray sources.
46.	SRCREG	-	Controls the x-ray source analysis for single-pass data over regions of known sources.

Table 2-1 (Continued)

47. SRCZON - Performs temporal variability analysis for single-pass data from known sources.

48. SUMOUT - Controls the data processing performed at the end of a file of input data.

49. SUNMUN (POSSUN) - A GSFC library routine which calculates the solar ephermeris (entry POSSUN).

50. TAPDAT - Writes a summary record containing fitted source intensity data for a 12-hour period.

51. TAPHED - Writes a file header record for the source intensity data tape.

52. TMPCAL - Saves HED1 and HED2 rate data corresponding to the same ecliptic scan angle for use by TMPSCN.

53. TMPSCN - Compares observations of the sky taken about 30 seconds apart for evidence of temporal variability.

54. UNITV - Calculates the unit 3-vector corresponding to the input 3-vector.

55. UNLOAD - A SACC system utility which unloads a magnetic tape from a given unit.

2.4.1.1

The highest level substructure is centered about the MAIN routine. This is a standard structure used for every program within the HEAO-A2 system which uses the MAX data base produced by program FRAPPE.[3] The MAIN routine controls the access to this data base, with calls to user specific routines which define what processing is done. Generally speaking, initialization for the job is performed through INIT; file initialization processing is performed through PROG1; data record processing through PROG2; and file termination processing through SUMOUT. In the case of the FCUT source analysis, the basic unit of data can be considered to be the 12 hour period which was a single nominal sun position for the spacecraft spin axis control.

2.4.1.2

Control of the analysis is handled through NAMELIST input to routine INIT. INIT also initialies a number of arrays, and also initializes a direct access disk file for temporary saving of results through INIT2 (see Appendix F). This file is used to store results from the single-pass source analysis which are then used for the 12-hour analysis.

2.4.1.3

PROG1 is used to recognize the start of a 12-hour period and set up internal data sets needed for that period. In addition it checks the available computer time to ensure that enough remains to process a 12-hour period. Normal set up includes acquisition from ESRCES of the set of catalogued sources which will be observed during the current 12-hour period, and the definition of the set of source regions, i.e. portions of the scan in which catalogued sources are located, using DEFREG.

---
3 HEAO-A2 FRAPPE Program Description and Operators Guide - CSC/TM-79/6231

Failsafe processing occurs when a call to REMTIM shows that too little time remains. A premature end-of-period processing is performed through a call to SUMOUT, and the job is terminated with an error message.

2.4.1.4

PROG2 processes each major frame (40.96 seconds) record of the selected period. It uses NOMINL to check that the experiment is in a normal state, ECONFC to ensure that data is free from excessive charged particles, and MFOV to verify that the moon is not in the field of view of any detector. Data which passes these tests is passed to SRCANL for the actual single-pass source analysis. This begins the largest part of the analysis.

2.4.1.5

SRCANL performs still more quality assurance processing. EOCC is called to calculate whether an extended shell about the earth is in the experiment field of view. Results of this FCUT analysis led to subsequent revisions of the flag on the MAX data base, with this calculation now a vestigal organ. Similarly, EPHEM and SPFLAG are used to check that the spacecraft is maintaining normal attitude and spin. Source analysis is performed using data passing all the above test.

This analysis is divided into three segments. The first, and most complex, is performed through a call to SRCREG. This is the calculation of source intensities for catalogued sources. The data for a single pass, or sum, over a define source region is fit using the catalog source positions, and results of this fit are analyzed. The second of the three analysis segments is a check of regions with no catalog sources, for constant observed rate. This is performed in NEWSRC. The third analysis segment is performed through TMPCAL, and is a check for short-term variations comparing the offset HED1 detector rates to the deck HED2 detector rates. To first order, a given position of the sky is observed by HED2 30 seconds before it is observed by HED1, and any difference should be a constant due to different internal detector constants.

2.4.1.6

SRCREG takes each record of data and uses it to form a set corresponding to a complete single-pass over the source region being observed. When the pass data is complete, SRCREG then calls ANLREG to perform the actual single-pass analysis.

For each detector with data for the pass, ANLREG calls DSLOAD to create the required matrix elements for the least squares fit (see Appendix D), and calls FITREG to calculate the fit parameters, all using Discovery Scaler data. It then does a detailed comparison of the fit to data. It then does a detailed comparison of the fit to the data, using 80-millisecond scaler data when available and Discovery Scaler data otherwise to calculate the chi-square and determine the goodness of fit. For this comparison, the source region is divided into zones dominated by individual sources and also the gaps between sources. Any zone with chi-square probability less than 2 percent is flagged, and if the bad zone corresponds to a source dominated one, it is analyzed for temporal variability through a call to SRCZON. This routine performs an auto-correlation (AUTOC) and a Fast Fourier Transform (FFT) analysis on the zone data. Additionally, ANLREG adds the results of the single-pass fit to the 12-hour disk file through DREAD and DWRITE, and adds data to the matrix elements being formed for a 12-hour least squares fit to the source region.

2.4.1.7

SUMOUT first ensures that all single pass data for the 12-hour period is completed by calling SRCREG. Then it performs the required 12-hour analysis through a call to FINALF. Finally, it re-initializes the accumulation arrays in COMMON and calls INIT2 to re-initialize the direct-access disk file for use with the next 12-hour period.

The call to SRCREG differs from the normal one only in that SRCREG is told that the region pass is done regardless of the position being observed, so that ANLREG will be called if any data has been saved for a source region. This completes loading of all 12-hour internal data sets.

FINALF first uses the 12-hour fit matrices calculated by ANLREG to perform a 12-hour least squares fit for a source region. It then reads the single-pass results for that region from the firect-access disk file and checks for constant source intensity. Sources which do not appear to be constant are flagged. Finally some ratios bwteeen the ratios observed in various Discovery Scalers for a given source are calculated and the results for the entire region are printed out, and also written onto magnetic tape through routines TAPDAT and TAPHED (see Appendix C).

2.4.2 Control and Access Sturcture

The control relationships between routines are shown in Figure 2-2, The Subroutine Cross-Reference Diagram. With the exception of MAIN, all routines are subroutines, and except for SACC system routines, all are coded in FORTRAN.

Execution is always initiated with the MAIN routine. Normally the run will terminate in routine INIT upon finding an end-of-file on the control input file, unit 5. The only other exit is in routine PROG1. If the job runs out of time, a message stating this is written to units 6 and 8, and the job is then terminated.

All common storage is in the form of FORTRAN Labeled Common. Access to the various areas is shown in the Common Block Access Diagram, Figure 2-3. In addition to use as data storage for access by several parts of the program, some blocks serve special purposes. For example, the SACC FTIO routines, eg. FREAD and FWRITE, transfer data between bulk media and contiguous core only, and, thus, a COMMON is used to ensure access to a block of contiguous core, eg. common TAPREC for the output data.

Subroutine

COMMON BLOCK	AVLREG	CLEAN	DEPREG	RIGIT	DREAD	DSLOAD	DWRITE	ECCNTL	EFFDET	EOCC	ESRCES	FINALF	FITREG	FOVIEW	FREAD / FWRITE	INIT	INIT2	MAIN (FLOAT)	MATFIT	MFOV	NEWSRC	NOMAL	PROG	PROG2	SCANGL	SPFLAG	SRCANL	SRCREG	SUMOUT	TAPDAT	TAPNED	TMPCAL	TMPSCN
BLVALU																W																	
CATCOM			X								X	R				W							R						W				
CHKTIM																W								N									
CONST											R					W							N										
CONSTF										R																							
CONST1																									R								
CURREC		R	R					X		X	R									R	R		W	R		R	R	R	N				R
DEBCOM											R					W						R	N	N					N				
DEFF						R			W				R																				
DETCOM														R																			
FCTCOM																W							N	R					R				
FERRISC															W			R															
FMOON		N																		W				W									
FOVCOM														R																			
INPARM																W		R															
MATRIX	X					X						X							X														
MODCOM																								W									
MODOPT																W								N									
NMNCOM																								R									
NXR-COV																W																	
FASTIM	W																													R			
PDPCOM											X																						
PRTSW		W										R				W		X		N	N			X			R						
PUNCOM																W																	
REGION	R		W			R						R	R														R	R			R		
SAVDIG		X		W												W		N									R						
SAVREG	R					R							R															W					
SCLASS											W																						
SLIST	W				W		R					X					W																
SLIST2					W							X																					
SRCFIT	X											X																					
SUMMY		N														W		X		R												R	
TAPREC															R															W	W		
TBECOM												R											W						X				
TPGCOM																W																	

Access Mode:
~~Legend~~

R - Read only

W - Write only

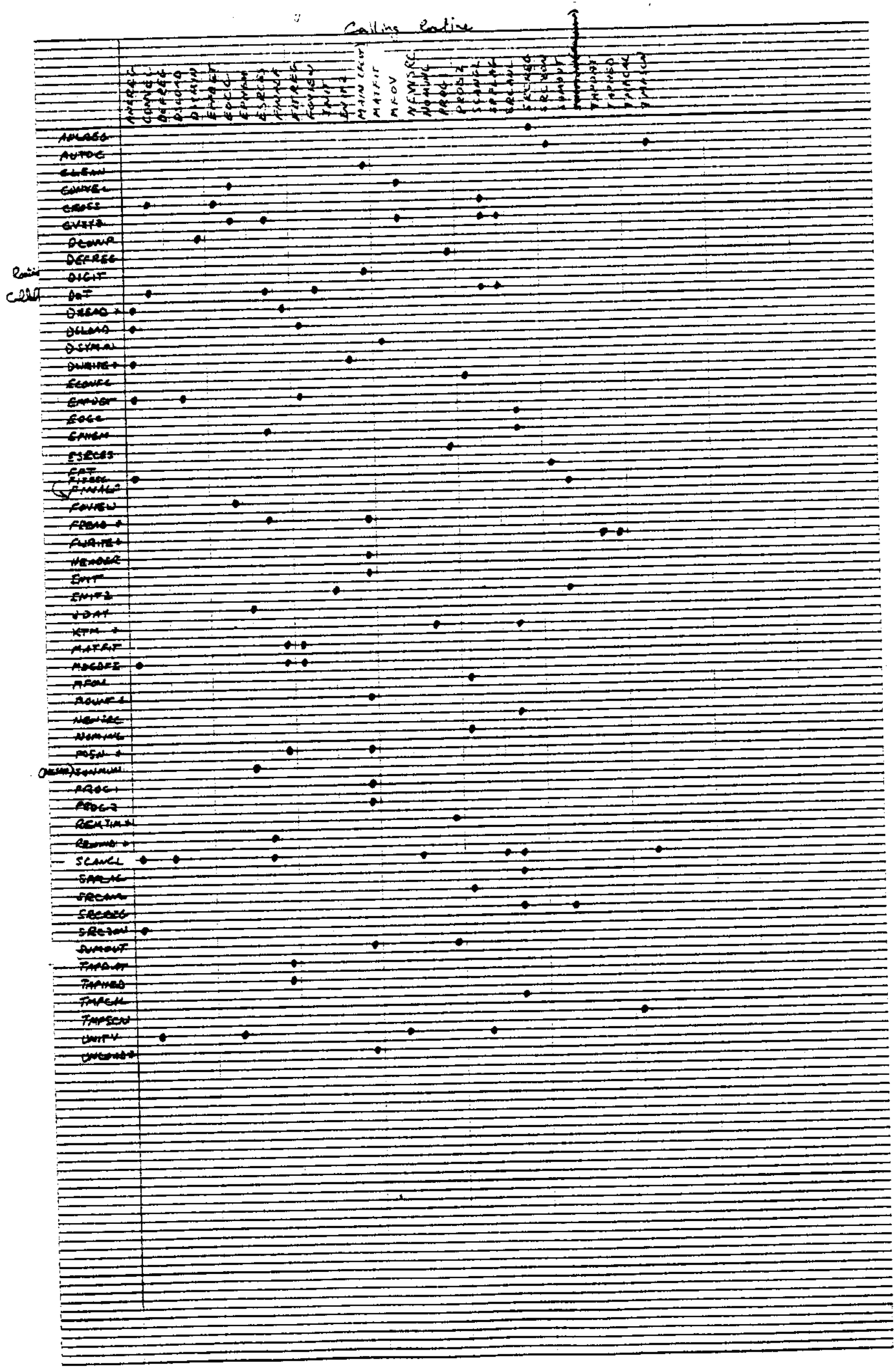
X - Read/Write

N - No access

COMMON ~~BLOCK CROSS Reference Diagram~~

Figure 2-3 Common Block Access Diagram.

Figure 2-2 Subroutine Cross-Reference Diagram



2.4.3 External Data Bases

2.4.3.1 Max Data Base

The MAX data base is the primary data library for the HEAO-A2 system. The details of its contents and structure are presented in the program document for program FRAPPE (ibid Ref.3). Program FCUT accesses this data as a purely sequential file, present on magnetic tape. Data is read by MAIN from unit 10 into a three-record first-in-first-out- buffer, which is needed to calculate the clean data flag. The data buffer is passed as a call sequence argument to all routines needing access.

2.4.3.2 HEAO-A2 X-Ray Source Catalog

The HEAO-A2 X-Ray Source Catalog (Appendix A) is accessed by routine ESRCES at the beginning of each 12-hour period. It is present on the system as a catalogued sequential disk file, ZBARS.XRAY.CATALOG. It is accessed through FREAD on unit 11. The data set is ordered by Source Right Ascension (1950), and each logical record contains the information for a single x-ray source.

2.4.3.3 FCUT Scratch File

This file is created by FCUT as a temporary file on disk, access as a "Direct Access" file. Each record has an index number and is accessed by that index through routines DREAD and DWRITE.

A record is used to accumulate the single-pass scaler rates for 12 hours of data for a given x-ray source, or region background. The data is placed into the record by ANLREG, and, at the end of the 12-hour period, is read from the file by FINALF for use in the 12-hour analysis. The format is specified in Appendix F.

2.4.3.4 FCUT Output Data

The largest part of the FCUT source analysis is presented on unit 8 as a print-out. This information consists of detailed results for each single pass over the sky as well as the complete results of the 12-hour summary analysis. Explicit details of this output are presented in Section 3, the Users Guide. The production data were permanently saved as microfilm, though paper printout was used for some special cases.

In addition to the detailed results above, a summary of the 12-hour analysis, including source rates and variability, was produced in computer readable form on magnetic tape. At the end of production processing, a version of these results was produced which has a single sequential file for each catalogued x-ray source. The files are ordered in the same order as the X-ray Source Catalog, i.e. by Source Right Ascension (Epoch 1950), and, within a file, the results are in time sequential order with earliest data first. The detailed formats of these data bases are presented in Appendix C.

3. FCUT Source Analysis User's Guide

This section is a guide to the interpretation of the printed output from the FCUT x-ray source analysis. The production printout is in two segments; a lineprinter listing of limited results, and a microfilm listing of the full analysis printout. This section will describe the microfilm listing, along with notation of those elements which also appear on the line printer listing. Information related to the running of the program is in the following section, the Operator's Guide.

3.1 Source Region Definition Listing

At the start of a 12-hour analysis period, the program selects from the x-ray source catalog those sources expected to be observed during the analysis period. The selected sources are ordered by increasing scan angle, and then separated into source regions for use in the fitting process.

The program prints the list of source regions and sources on both the microfilm and the lineprinter. For each source region, the region index, start and scan angles in degrees, and the source indices, names and scan angles in degrees are all printed. These are necessary for the interpretation of the single-pass analysis. A sample listing is shown in Figure 3-1.

3.2 HED1-HED2 Temporal Variation Analysis

For all clean data, the rate observed with HED2 for a given scan angle is compared with that for HED1 which observes the same scan angle approximately 30 seconds later. Taken as an unit of one major frame, or about 8 degrees in scan angle, the chi square for a constant rate is calculated. If the data is unacceptable as a constant difference, then the time and scan angle at the start of the major frame for

***** SOURCE REGIONS *****

REGION	START ANGLE	END ANGLE	SOURCES:		SCAN ANGLE:
1	16.4	28.4	1	4U0316+41	22.35
2	37.5	49.5	1	4U0241+61	43.47
3	68.7	86.7	1	3U2041+75	74.70
4	112.3	125.8	1	4U1651+39	118.27
			2	4U1627+39	119.77
5	211.2	233.9	1	4U1446-55	217.23
			2	4U1436-56	218.91
			3	A1452-60	221.40
			4	A1439-61	223.18
			5	A1415-60	223.61
			6	4U1425-61	223.71
			7	XRN 1436-62	224.02
			8	MX1418-61	224.23
			9	4U1416-62	225.12
			10	MX1406-61	225.35
			11	A1354-64	227.94
6	262.1	288.5	1	4U0540-69	268.09
			2	4U0532-66	271.24
			3	4U0538-64	273.18
			4	H0500-56	282.53
7	345.5	357.5	1	4U0344+11	351.54

Figure 3-1

HED2 data are printed out, on both microfilm and line printer, along with the number of rates accumulations used and the total chi square. The number of bins will be 512 if Multiscaler data is used rather than Discovery Scaler data. Finally, the auto-correlation results are printed. Figure 3-2 contains a sample printout. From the time of the data and the scan angle one can immediately determine if a known source was in the field of view, and procede from there.

3.3 New Source Search Results

For all data not within a source region, the Discovery Scaler data for each detector is tested against a constant rate for a major frame. If the rate is deemed to vary, the detector name, time and scan angle at the start of the major frame, and chi square are printed on both the line printer and microfilm followed by the actual 1.28-second rate accumulations for the data tested. Figure 3-3 shows a sample printout.

3.4 Single Pass Source Region Analysis

The single pass results of the fit to the data for each detector start with a line giving the detector name, followed by a line for each zone within the region giving the results for that zone, ending with a two line summary of the quality of the fit to the region. If a given zone has a bad fit, a line is printed on both microfilm and line printer with this message, and for a source contributing more than half the rate, the results of an auto-correlation and Fast Fourier Transform (FFT) follows. Figure 3-4(a) shows a region pass printout for one detector.

The zone fit line contains the following information:

- The major frame number and data point number at the start of the zone. The major frame number is the

```
EMPORAL VARIATIONS FOUND AT: 414  10555321
CAN ANGLE= 12.99   NUMBER OF BINS=512   TOTAL CHI SQUARE= 646.257
ESULTS OF AUTO CORRELATION ANALYSIS:
```

1.00	0.25	0.28	0.29	0.25	0.26	0.25	0.29	0.26	0.22	0.18	0.23	0.26	0.16	0.23	0.24
0.23	0.22	0.19	0.24	0.16	0.27	0.24	0.24	0.24	0.22	0.27	0.21	0.23	0.28	0.19	0.24
0.19	0.19	0.19	0.18	0.19	0.22	0.25	0.14	0.19	0.14	0.14	0.16	0.19	0.22	0.14	0.23
0.19	0.14	0.19	0.16	0.23	0.13	0.20	0.16	0.18	0.13	0.12	0.16	0.11	0.13	0.13	0.09
0.11	0.09	0.10	0.08	0.12	0.15	0.12	0.13	0.13	0.15	0.12	0.08	0.16	0.16	0.12	0.07
0.03	0.08	0.09	0.12	0.11	0.11	0.07	0.06	0.09	0.12	0.09	0.13	0.11	0.07	0.13	[illegible]
0.11	0.16	0.08	0.11	0.12	0.12	0.11	0.10	0.12	0.09	0.09	0.07	0.11	0.06	0.07	0.06
0.06	0.10	0.11	0.09	0.08	0.07	0.09	0.10	0.12	0.11	0.12	0.11	0.02	0.08	0.12	0.05
0.10	0.09	0.05	0.11	0.04	0.05	0.04	0.10	0.00	0.05	0.08	0.04	0.05	0.06	0.06	0.03
0.09	0.13	0.09	0.08	0.06	0.08	0.14	0.07	0.11	0.06	0.02	0.04	0.09	0.09	0.03	0.04
0.11	0.03	0.09	-0.00	-0.00	-0.01	0.03	0.04	0.02	0.06	0.01	0.07	0.05	0.09	0.05	0.06
0.04	0.00	0.05	0.04	0.00	0.05	0.01	0.02	0.00	0.06	0.04	-0.03	0.02	0.02	-0.03	-0.02
-0.01	-0.01	-0.00	-0.02	0.03	0.04	-0.03	0.01	0.03	0.03	0.00	-0.00	0.05	-0.00	-0.03	0.02
-0.01	-0.06	-0.01	-0.02	0.01	-0.02	-0.01	-0.02	0.01	-0.03	-0.05	-0.02	-0.07	0.00	-0.07	-0.07
-0.06	-0.03	-0.02	-0.07	0.00	0.00	-0.03	-0.05	-0.06	-0.02	-0.04	-0.06	-0.01	-0.04	-0.06	-0.03
-0.06	-0.02	-0.03	-0.04	-0.01	-0.01	-0.08	-0.04	-0.02	-0.06	-0.00	-0.02	-0.03	-0.02	-0.08	-0.04

Figure 3-2

```
BAD ZONE FIT IN HED2, DAY  414 MSEC  10555321, REGION  1 MF  4 ZONE FLAG  -1, ZONE FOR 40414694
******************************
      END OF PASS FOR REGION  1

NONUNIFORM DS DATA IN HED  AT DAY 414 MSEC 13261721.  Y-AXIS S.A. = 101.6 DEG.
******************     CHISQUARE =      54.3
             12.  11.   8.   8.  19.  10.  11.  19.  11.  17.  14.  12.  19.  13.  15.  13.
             18.  19.  18.  22.  15.   8.   7.  24.  22.  18.  15.  10.   9.   6.   8.  19.
      END OF PASS FOR REGION  3
```

Figure 3-3

```
REGION PASS ANALYSIS FOR HED3
ZONE FIT-MFA 1, PT #   1, ZONE TYPE  0, NDF   42, CHISQ   41.5, PROB 0.495
ZONE FIT-MFA 1, PT #  13, ZONE TYPE -1, NDF  -16, CHISQ   15.8, PROB 0.470
ZONE FIT-MFA 2, PT #  32, ZONE TYPE -2, NDF    6, CHISQ    5.0, PROB 0.548
ZONE FIT-MFA 2, PT #   9, ZONE TYPE -7, NDF    4, CHISQ    1.0, PROB 0.904
ZONE FIT-MFA 3, PT #  16, ZONE TYPE -5, NDF   16, CHISQ   23.7, PROB 0.164
ZONE FIT-MFA 4, PT #   5, ZONE TYPE -5, NDF    7, CHISQ   19.0, PROB 0.008
BAD ZONE FIT IN HED3, DAY  414 MSEC  33281161, REGION  5 MF  4 ZONE FLAG  -3, ZONE FOR 40416-62
****************************
ZONE FIT-MFA 4, PT #  15, ZONE TYPE  0, NDF   48, CHISQ   48.2, PROB 0.465
FIT OF REGION 5, SCAN ANGLES FROM 211.2 TO 233.0 FOR 44 SOURCES IN HED3, STARTING ON DAY 414 MSEC 33281161
     NDF=  147, CHISQ=        154.1 , PROB= 0.327
```

Figure 3-4 (a)

```
-BAD ZONE FIT IN HED1, DAY  466 MSEC  85935307, REGION  4 MF  1 ZONE FLAG   1, ZONE FOR 461907+09
******************************
     AUTOCORRELATION RESULTS FOR ZONE  1, WITH BIN = 1.030 SECS
       0.959655   0.919618   0.879200   0.839058   0.799056   0.759190   0.719498   0.680013
       0.640763   0.601778   0.563086   0.524749   0.485702   0.449066   0.411839   0.378052
       0.336733   0.302912   0.267619   0.232881   0.198730   0.165195   0.132303   0.100067
       0.066574   0.037793   0.007775  -0.021451  -0.049856  -0.077408  -0.104080  -0.129640
      -0.154660  -0.178509  -0.201359  -0.223179
     FFT ANALYSIS:    74 NON-ZERO POINTS OUT OF   128, WITH AVERAGE COEFF =    3.8913    AND STD =    17.31
     BIN               FREQ                 TTT                PWR                PROB
      1          0.97656E-01             10.240             39.473             0.0
      2          0.19531                  5.1200             9.4532             0.78442E-04
      3          0.29297                  3.4133             4.9172             0.73196E-02
```

Figure 3-4 (b)

index of that frame in the region storage array. The data point number is the index for the rate word within that major frame.

- The zone type. The zone type is 0 if this is all background data. A non-zero zone type is the index of the brightest source being observed. It is positive if the source contributes at least half the rate, and negative otherwise.
- The number of degrees of freedom for the least squares fit.
- The zone chi-square for the fit
- The chi-square probability that the data represent a sub-sample of the model.

The region summary includes, in order:

- The region index as printed in the region definition listing.
- The start and end scan angles for the region.
- The number of sources in the region.
- The detector name.
- The time at the start of the first major frame of data used for the fit.
- The number of degrees of freedom, chi-square, and chi-square probability for the last squares fit to the region.

The bad zone message includes the following:

- The detector name.
- The time at the start of the pass over the region.
- The region index.

- The major frame index for the zone.
- The zone type, and an index followed by the source name or the word "BACKGROUND"

The source zone temporal analysis printout Figure 3-4(b) starts with a line on the line printer giving the source name and the detector being analyzed. This is followed by the auto-correlation results. These include:

- The zone type index.
- The rate bin size in seconds.
- The results of the auto-correlation out to an interval equal to the zone length.

The auto correlation results are followed by the FFT analysis. These results include:

- The true number of rate intervals.
- The total used (always a power of 2).
- The average FFT coefficient and standard deviation.
- For each frequency analyzed which has a statistical probability of less then 4 percent of coming from a constant rate,

a) The frequency index

b) The frequency

c) The corresponding period in seconds

d) The power, is the square of the ratio of the absolute value of the coefficient to the standard deviation.

e) The probability, where Prob. = exp(-power).

3.5 Other Single Pass Analysis Messages

Two other warning messages may be sent to the line printer. These shown in Figure 3-5a and 3-5b.

```
****DIAGONAL ELEMENTS ARE ZERO*****************
-DSYMIN CAN NOT INVERT THE MATRIX ***REARRANGE ROWS&COLUMNS
```

Figure 3-5 (a)

```
BAD ZONE REMOVED-FITREG ECCE. HFMF,HFPT,HLMF,HLPT     7     1,     1     24, CHISQ     44.7, NDF     22, PROB 0.00326
************
```

Figure 3-5 (b)

The first of these is a diagnostic message noting that the determinent of the fit matrix was zero, which happens when ever an expected source is not actually observed. This causes no problems, but, of course, no results will be there for that source in this pass.

The second of these messages results when a trial fit to a background zone indicates a poor fit. The offending background zone is removed and another fit is made. This may result in a message which indicates that no data was left after the offending zone is removed. In this case the program skips analysis of this pass.

3.6 12-Hour Region Analysis

At the end of the 12-hour analysis period, a summary of the single-pass results, and the results of the analysis of a 12-hour accumulation of data, are printed for each region. These results are organized by region, and, within a region, a section is present for the background and for each source. Figure 3-6 shows the start of a region summary, and the background results for one detector.

The region summary begins with a label line printed on both the line printer and the microfilm. This label includes the region index, start and end scan angles, number of sources, and the time interval covered by the analysis. The label line is followed on the microfilm by the background summary for each detector, and then the summary for each source within the region. The only summaries written to the line printer are those for elements with apparent variability within the 12-hour period.

3.6.1 The Background Summary

The background summary starts with one line giving the detector index and name. This is followed by four lines for each pass over the region giving the fitted Discovery

Figure 3-6

1

```
*************
* REGION  1 *      BEG SCAN ANG=  16.35     END SCAN ANG=  28.35        NUMBER OF SOURCES= 7      DAY 4?4   725?4E0 TO 4?4  503?05?1
*************
```

DETECTOR 1 HED1
****
PASS BY PASS BACKGROUND RESULTS

	DS 1.2	ERROR	DS 3.4	ERROR	DS 5.6	ERROR	DS 7.8	ERROR
LEFT	0.146E-01	0.880E-03	0.376E-02	0.341E-03	0.154E-02	0.225E-03	0.634E-02	0.425E-03
RIGHT	0.236E-01	0.563E-03	0.516E-02	0.381E-03	0.407E-02	0.367E-03	0.960E-02	0.474E-03
DIF EXT	0.178E-01	0.260E-02	0.276E-02	0.101E-02	0.496E-02	0.959E-03	0.611E-02	0.125E-02
INTERNAL	0.577E-02	0.211E-02	0.241E-02	0.819E-03	-0.697E-03	0.781E-03	[illegible]	[illegible]
LEFT	0.151E-01	0.124E-02	0.359E-02	0.439E-03	0.156E-02	0.385E-03	0.663E-02	0.615E-03
RIGHT	0.260E-01	0.142E-02	0.523E-02	0.506E-03	0.320E-02	0.447E-03	0.102E-01	0.798E-03
DIF EXT	0.214E-01	0.371E-02	0.722E-02	0.177E-02	0.321E-02	[illegible]	0.659E-02	[illegible]
INTERNAL	0.459E-02	0.304E-02	0.203E-02	0.108E-02	-0.170E-04	0.967E-03	0.719E-02	0.151E-02
LEFT	0.143E-01	0.371E-03	0.432E-02	0.357E-03	0.179E-02	0.345E-03	0.626E-02	0.487E-03
RIGHT	0.257E-01	0.963E-03	0.515E-02	0.403E-03	0.370E-02	0.369E-03	0.941E-02	0.550E-03
DIF EXT	0.224E-01	0.258E-02	0.162E-02	0.106E-02	0.375E-02	0.102E-02	0.620E-02	0.146E-02
INTERNAL	0.272E-02	0.211E-02	0.852E-02	0.865E-03	-0.498E-04	0.675E-03	0.321E-02	0.118E-02
LEFT	0.157E-01	0.116E-02	0.347E-02	0.532E-03	0.145E-02	0.466E-03	0.634E-02	0.518E-03
RIGHT	0.261E-01	0.147E-02	0.551E-02	0.675E-03	0.412E-02	0.551E-03	0.844E-02	0.657E-03
DIF EXT	0.205E-01	0.365E-02	0.402E-02	0.169E-02	0.527E-02	0.148E-02	0.417E-02	0.165E-02
INTERNAL	0.563E-02	0.311E-02	0.150E-02	0.142E-02	-0.114E-02	0.125E-02	0.431E-02	0.139E-02
LEFT	0.154E-01	0.112E-02	0.465E-02	0.451E-03	0.257E-02	0.474E-03	0.664E-02	0.560E-03
RIGHT	0.255E-01	0.130E-02	0.617E-02	0.578E-03	0.358E-02	0.500E-03	0.930E-02	0.660E-03
DIF EXT	0.195E-01	0.242E-02	0.290E-02	0.149E-02	0.208E-02	0.139E-02	0.522E-02	0.170E-02
INTERNAL	0.559E-02	0.227E-02	0.222E-02	0.123E-02	0.150E-02	0.107E-02	0.467E-02	[illegible]
LEFT	0.146E-01	0.116E-02	0.325E-02	0.434E-03	0.244E-02	0.428E-03	0.624E-02	0.570E-03
RIGHT	0.251E-01	0.142E-02	0.475E-02	0.534E-03	0.402E-02	0.528E-03	0.948E-02	0.702E-03
DIF EXT	0.207E-01	0.362E-02	0.255E-02	0.135E-02	0.312E-02	0.134E-02	0.617E-02	0.178E-02
INTERNAL	0.439E-02	0.304E-02	0.179E-02	0.113E-02	0.913E-03	0.117E-02	0.371E-02	0.149E-02
LEFT	0.146E-01	0.110E-02	0.333E-02	0.512E-03	0.146E-02	0.459E-03	0.757E-02	0.667E-03
RIGHT	0.267E-01	0.108E-02	0.516E-02	0.502E-03	0.464E-02	0.467E-03	0.917E-02	0.655E-03
DIF EXT	0.276E-01	0.303E-02	0.360E-02	0.147E-02	0.626E-02	0.136E-02	0.322E-02	0.184E-02
INTERNAL	0.289E-02	0.228E-02	0.156E-02	0.110E-02	-0.162E-02	0.106E-02	0.555E-02	[illegible]
LEFT	0.153E-01	0.757E-03	0.426E-02	0.309E-03	0.216E-02	0.272E-03	0.662E-02	0.476E-03
RIGHT	0.257E-01	0.849E-03	0.521E-02	0.347E-03	0.316E-02	0.304E-03	0.944E-02	0.499E-03
DIF EXT	0.204E-01	0.274E-02	0.187E-02	0.914E-03	0.198E-02	0.807E-03	0.558E-02	[illegible]
INTERNAL	0.529E-02	0.187E-02	0.334E-02	0.744E-03	0.118E-02	0.654E-03	0.389E-02	[illegible]
LEFT	0.153E-01	0.605E-03	0.351E-02	0.322E-03	0.227E-02	0.259E-03	0.578E-02	0.454E-03
RIGHT	0.265E-01	0.911E-03	0.541E-02	0.364E-03	0.344E-02	0.378E-03	0.994E-02	0.517E-03
DIF EXT	0.219E-01	0.239E-02	0.775E-02	0.957E-03	0.231E-02	0.866E-03	[illegible]	0.135E-02
INTERNAL	0.444E-02	0.115E-02	0.167E-02	0.782E-03	-0.113E-02	0.724E-03	0.175E-02	[illegible]
LEFT	0.134E-01	0.966E-03	0.350E-02	0.462E-03	0.215E-02	0.392E-03	0.557E-02	0.595E-03
RIGHT	0.226E-01	0.112E-02	0.552E-02	0.537E-03	0.304E-02	0.467E-03	0.840E-02	0.615E-03
DIF EXT	0.172E-01	0.291E-02	0.358E-02	0.179E-02	0.175E-02	0.170E-02	0.564E-02	0.162E-02
INTERNAL	0.493E-02	0.240E-02	0.154E-02	0.115E-02	0.129E-02	0.989E-03	0.275E-02	[illegible]
LEFT	0.141E-01	0.866E-03	0.369E-02	0.364E-03	0.146E-02	0.319E-03	0.574E-02	0.474E-03
RIGHT	0.268E-01	0.905E-03	0.524E-02	0.409E-03	0.307E-02	0.359E-03	0.987E-02	0.572E-03
DIF EXT	0.250E-01	0.238E-02	0.306E-02	0.108E-02	0.474E-02	0.945E-03	0.804E-02	0.140E-02
INTERNAL	0.196E-02	0.194E-02	0.218E-02	0.877E-03	-0.872E-03	0.770E-03	[illegible]	[illegible]

12 HOUR BACKGROUND RESULTS

	DS 1.2	ERROR	DS 3.4	ERROR	DS 5.6	ERROR	DS 7.8	ERROR
LEFT	0.148E-01	0.288E-03	0.382E-02	0.119E-03	0.192E-02	0.108E-03	0.626E-02	0.154E-03
RIGHT	0.254E-01	0.326E-03	0.525E-02	0.134E-03	0.364E-02	0.127E-03	0.947E-02	0.174E-03
DIF EXT	0.210E-01	0.655E-03	0.250E-02	0.352E-03	0.338E-02	0.331E-03	0.632E-02	0.457E-03
INTERNAL	0.444E-02	0.646E-03	0.279E-02	0.267E-03	0.254E-03	0.244E-03	0.315E-02	0.346E-03

TEMPORAL CHI SQUARE AND PROBABILITY

	DS 1.2	PROB	DS 3.4	PROB	DS 5.6	PROB	DS 7.8	PROB
DIF EX	7.40	0.617	4.69	0.898	10.5	0.475E-01	5.14	0.519
INTERNAL	3.47	0.970	6.67	0.760	15.2	0.136	8.52	0.578

Scaler rates for the Left Field of View (FOV) of the detector (always 3° x 3°), the Right FOV (either 3° x 1 1/2° or 3° x 6°), the "diffuse external" rate (Large FOV - small FOV), and the "internal background" rate (2*small FOV - Large FOV) respectively. For a given "field of view", the line gives the rate and error in counts per second for each pair of Discovery Scalers. While a given FOV contributes to only one Discovery Scaler, the fitting process mixes data from the two FOV's and thus, for example, the "LEFT" rate is not due to only single scaler but rather the pair indicated.

The single pass summary is followed by four lines giving the same results for a fit to 12 hours of accumulated data for the region. This is followed by two lines giving the chi-square and probability that the single pass results come from a constant rate equal to that given by the 12-hour fit.

3.6.2 The Source Summary

A source summary begins with a label line giving the source index, name, position in the sky and also relative to the scan plane. This is followed by a summary for each detector of the single pass and 12-hour fit, and, finally, by additional multi-detector 12-hour results. A sample source label, a single detector summary, and the multi-detector results are shown in Figure 3-7.

The single pass results are given with a single line for each pass containing the rate and error, normalized to the 3° FOV, for each pair of Discovery Scalers. These are followed by a line giving the rates resulting from the 12-hour region fit, which is followed by a line giving the chi-square and probability that the source rate is a constant equal to the 12-hour rate.

```
****************************
* SOURCE: 1 4U0210+41     *      AT  RIGHT ASCENSION  49.12   DECLINATION  41.35    ,  -0.76 DEG. OFF SCAN PLANE
****************************

DETECTOR  1      HED1
********
```

PASS BY PASS SOURCE RESULTS

DS 1.2	ERROR	DS 3.4	ERROR	DS 5.6	ERROR	DS 7.8	ERROR
0.666E-01	0.219E-02	0.374E-02	0.880E-03	0.107E-01	0.810E-03	0.853E-02	0.106E-02
0.697E-01	0.337E-02	0.502E-02	0.116E-02	0.119E-01	0.102E-02	0.822E-02	0.163E-02
0.681E-01	0.247E-02	0.505E-02	0.101E-02	0.111E-01	0.576E-03	0.112E-01	0.138E-02
0.881E-01	0.787E-02	0.230E-02	0.359E-02	0.910E-02	0.314E-02	0.612E-02	0.249E-02
0.685E-01	0.287E-02	0.367E-02	0.123E-02	0.882E-02	0.106E-02	0.9[illegible]3E-02	0.140E-02
0.675E-01	0.347E-02	0.626E-02	0.127E-02	0.696E-02	0.126E-02	0.963E-02	0.167E-02
0.657E-01	0.225E-02	0.341E-02	0.917E-03	0.964E-02	0.806E-03	0.947E-02	0.129E-02
0.657E-01	0.266E-02	0.417E-02	0.106E-02	0.106E-01	0.565E-03	0.121E-01	0.150E-02
0.726E-01	0.257E-02	0.520E-02	0.123E-02	0.125E-01	0.106E-03	0.137E-01	0.141E-02
0.626E-01	0.279E-02	0.515E-02	0.125E-02	0.100E-01	0.111E-02	0.650E-02	0.164E-02

12 HOUR SOURCE RESULTS

DS 1.2	ERROR	DS 3.4	ERROR	DS 5.6	ERROR	DS 7.8	ERROR
0.671E-01	0.835E-03	0.457E-02	0.344E-03	0.103E-01	0.314E-03	0.974E-02	0.446E-03

TEMPORAL CHI SQUARE AND PROBABILITY

DS 1.2	PROB	DS 3.4	PROB	DS 5.6	PROB	DS 7.8	PROB
9.97	0.353	7.23	0.614	17.5	0.410D-07	17.4	0.435D-07

Figure 3-7 (a)

STABILITY FLAG= 0   ON-AXIS RELATIVE VARIANCE= 1.0086

HARDNESS RATIOS

	1	2	3	4	5	6	7
	MED	MED	MED	MED	HED1 HED2 HED3	HED1 HED2 HED3	HED1 HED2 HED3
RATIO	1.30	4.27	0.306	0.382	0.673E-01	[illegible]	0.153
ERROR	0.151	0.369	0.146E-01	0.283E-01	0.519E-02	0.1[illegible]	0.50[illegible]E-02
RATIO	1.30	4.23	0.306	0.382	0.598E-01	[illegible]	0.1[illegible]
ERROR	0.151	0.368	0.146E-01	0.283E-01	0.836E-02	0.266	0.677E-02
RATIO	1.30	4.27	0.306	0.382	0.708E-01	[illegible]	0.105
ERROR	0.151	0.369	0.146E-01	0.287E-01	0.645E-02	0.166	0.486E-02

1

Figure 3-7 (b)

After the last detector analysis, normally HED-3, a line is printed giving the source temporal stability flag, and the calculated an-axis variance. The stability flag is 1 if the 12-hour variability tests for all detectors for the source indicate a constant rate, and is set to 0 otherwise. The meaning of the on-axis variance is described in detail in Appendix E. To first order one only knows that the variance is expected to be about 1.0 for a constant source.

The last items given are the ratios between various 12-hour rates. The first line across the page is the ratio number as discussed in Section 2.3.4.4. The second line indicates the detectors used for the ratio. Note that the first four ratios use only the MED, while the last three are the ratio of elements within one of the HED's. The results are printed as a pair of lines giving the ratio and its error. The three pairs of lines are necessary to give the results of the last three ratios for HED1, HED2, and HED3, respectively.

SECTION 4 - OPERATOR'S GUIDE

This section presents the information for the FCUT x-ray source analysis production data processing. This includes job submission requirements and those checks necessary to ensure that the run completed successfully. In addition, information is given related to the final data base structure for the summary output data.

4.1 Job Submission

This program is used only on the SACC 360/91 because of its requirements for large memory and much CPU time. It is to be generall submitted by card deck for running overnight or over the weekend. All MAX data is processed through this program.

The following files must be present as catalogued data sets on the SACC system to run the program:

LOAD MODULE: ZBARS.FCUT.LOAD
MEMBER NAME: FCUT
X-RAY SOURCE CATALOG: ZBARS.XRAY.CATALOG

If not present, they must be recovered from the SACC ASM2 archival system.

The source code is present in the SACC system, either on disk or archived, as PDS files:

ZBARS.FCUT.SOURCE
ZBARS.FCUT.SOURCE2

They are not needed for job execution, but contain JCL for creating the LOAD module as a PDS member.

Additional input data are:

6250 BPI MAX data tapes on UNIT 10
NAMELIST FCUT input data on UNIT 5, one set per tape.

The NAMELIST parameters which must be changed are:

DTAPE - the volume - serial number of the input MAX tape.

NFILE - the first file from the MAX tape to be analyzed.

Output data sets are:

UNIT 6 - Run printout summary

UNIT 8 - Analysis print files for microfilm (SD4060)

UNIT 20 - FCUT Rates Summary

Computer Time Required:

CPU: 5 minutes per day of data analyzed

IO : 3 minutes per day of data analyzed

Sample JCL:

```
//ZBARSF15 JOB (SB0182188J,P,FCUT01,050015),216
//*THISDATE
//*FCUT SOR
// EXEC LINKGO,REGION.GO=500K
//LINK.NEWLIN DD DSN=ZBARS.FCUT.LOAD,DISP=SHR
//LINK.SYSLIN DD *
 INCLUDE NEWLIN(FCUT)
 ENTRY MAIN
/*
//*      MICROFILM TAPE ON UNIT 8
//GO.FT08F001 DD UNIT=(800,,DEFER),DISP=(OLD,KEEP),
//  LABEL=(1,SL),VOL=SER=XR0191,DSN=FCUT.OUTPUT,
//  DCB=(RECFM=FB,LRECL=133,DEN=2,BLKSIZE=2527)
//*      INPUT 6250 BPI MAX TAPE ON UNIT 10
//GO.FT10F001  DD UNIT=(6250,,DEFER),DISP=(OLD,PASS),LABEL=(1,NL),
//  DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=4),VOL=SER=MAXTAP
//*      X-RAY SOURCE CATALOG ON UNIT 11
//GO.FT11F001 DD DSN=ZBARS.XRAY.CATALOG,DISP=SHR
//*      FCUT SCRATCH FILE ON UNIT 15
//GO.FT15F001  DD DSN=ZBAKT.FCUT.SCRATCH,DISP=(NEW,DELETE),UNIT=2314,
//  SPACE=(TRK,(40)),DCB=(RECFM=F,LRECL=3076,BLKSIZE=3076)
//*      FCUT OUTPUT TAPE ON UNIT 20
//GO.FT20F001 DD UNIT=(6250,,DEFER),LABEL=(1,NL),DISP=(NEW,KEEP),
//  DCB=(RECFM=F,BLKSIZE=3472,DEN=3),VOL=SER=XR0161
//GO.SYSUDUMP DD SYSOUT=A
//GO.DATA5 DD *,DCB=BUFNO=1
 &FCUT DTAPE='XR0102',NFILE=1,IDFSPA=0,INXRFG=0,ISORFG=1, &END
/*
END OF DATA
```

4.2 Job Analysis

The FCUT Source Analysis program has been defensively programmed, and is not very suspectible to system abends. The few processing failure mode are easily recognized. These are:

- Erroneous Namelist control data Format - the message "END OF FILE ON INPUT CARDS STOP PROGRAM", results when an end-of-file is found on UNIT 5 while trying to get the NAMELIST data.

  If more than one Namelist set is present, an error simply results in termination at that point. Thus the operator should always check that the proper number of tapes were mounted.

- Error in processing options - the message "INCORRECT OPTIONS SPECIFIED - REVIEW NAMELIST INPUT" results if you do not have ISORFG = 1, and processing is halted.

- Insufficient JOB time - FCUT checks remaining job time, and stops processing early if too little remains. The job terminates with the message

```
FCUT ENDING DUE TO TOO LITTLE TIME. ICPU =    92, ICTIM =    20 SECONDS REMAINING
```

If this happens, the job must be resubmitted to process the remaining data. To find the file number for the submission, start at the end of the printout and page backwards until the source region list is printed.

```
*****  SOURCE REGIONS  *****

REGION  START ANGLE   END ANGLE   SOURCES:              SCAN ANGLE:
  1        16.4          28.4      1   4U0316+41          27.36
  2        37.5          45.5      1   4U0241+61          43.14
  3        68.7          80.7      1   3U2041+75          74.72
  4       112.3         124.3      1   4U1651+39         118.29
  5       211.2         234.0      1   4U1446-55         217.22
                                   2   4U1476-56         218.92
                                   3   4U1510-59         219.50
                                   4   A1450-60          221.78
                                   5   A1439-61          222.17
                                   6   A1415-60          222.63
                                   7   4U1428-61         223.72
                                   8   XGN 1436-62       224.02
                                   9   MX1418-61         224.24
                                  10   4U1416-62         225.13
                                  11   MX1405-61         225.77
                                  12   A1354-64          227.97
  6       265.2         288.5      1   4U0537-65         271.23
                                   2   4U0579-64         273.17
                                   3   4U0300-56         282.50
  7       345.5         357.5      1   4U0344+11         351.54
```

Continue paging back through the region summaries to the "Region 1" header -

```
*************
* REGION  1 *
*************
```

A few lines before this, one will find a message

```
END OF MAX FILE    4      TOTAL NUMBER OF RECORDS=  982
*******************************************************************************************
                                                HEADER RECORD FOR INPUT MAX TAPE

                          FRAPPC TAPE NAME XF0250 A DAY 415/78 USING IPD TAPE  XR0209,XR02_0
*******************************************************************************************
```

The MAX file number indicated is the last one completed. The resubmission should be done with NFILE - one larger than this, and with a new tape on UNIT 20. This output tape should later be merged with the first tape, with the first file from the resubmission overwriting the last file on the first tape.

FCUT normally ends with the message "END OF PROCESSING". It will normally produce two files for each day of data on the UNIT 20 tape, with each file having about 50 blocks. Any run which has less than half of this data should be brought to the attention of the analyst as it may indicate a spurious experiment state.

4.3 Source Rates Summary Data Base

The source rate summary tapes are merged onto a 6250 BPI tape in time order. The full duration of the mission results in about 4 of these tapes. To form the final data base, the data on these tapes were sorted to produce a single file for each source, with the data for the source in proper time order. These four tapes, with about 90 source files per tape at 6250 BPI, form the summary data base. The sorting was performed with program SORTFCUT. This job requires about half the available SACC scratch disk space and takes about one hour of computer time. Do not do this without the direct involvement of the task leader. These tapes are in slots: XR0337-XR0340.

4.4 Microfilm Output

The UNIT 8 output is a huge line printer listing. To save paper, space, and user time, this output is sent to the SD4060 for the production of microfilm. There are normally about 1,000 frames for four days of data. No hardcopy is desired for production runs.

APPENDIX A - THE HEAO-A2 X-RAY SOURCE CATALOG

The HEAO-A2 X-ray source catalog is a data base containing objects of astronomical interest to the experiment. A subset of this data base, consisting of all known x-ray emitting objects, is maintained on the SACC system for use with the HEAO-A2 data processing and analysis system. This appendix documents both forms of the catalog.

A.1 The HEAO-A2 Source Library

This is the primary form of the catalog. The catalog is maintained on the Laboratory for High Energy Astrophysics Graphics Processing System PDP-11/70. It is in the form of an ASCII source file, RD1:[300,125] LIBR.TWO, in standard DEC format.

For each astrophysical object in the catalog there are two 132-character lines giving the information for the object. The information consists of the following variables in sequence.

Line 1:

Name	-	catalog name of the object
Comment	-	16 characters usually used for a secondary name. For objects with no observed x-ray emission, the Name is blank, while this field contains the name.
RA50	-	Celestial Right Ascension (Epoch 1950) in degrees
GLON	-	Galactic Longitude in degrees
ELON	-	Ecliptic Longitude (Epoch 1978) in degrees
RA78	-	Celestial Right Ascension (Epoch 1978) in degrees

INTENSITY - Maximum Source X-ray rate in equivalent UHURU counts/seconds

VARIABILITY - Variability factor observed in X-ray rate

Class Flag 1- X-ray source classification flag. "1" for observed x-ray sources.

Class Flag 2- Astrophysical classification flag.

Comment 2 - 20 character comment field

Line 2:

DEC50 - Celestial Declination (Epoch 1950) in degrees

GLAT - Galactic Latitude in degrees

ELAT - Ecliptic Latitude (Epoch 1978) in degrees

DEC78 - Celestial Declination (Epoch 1978) in degrees

ERRBOX - Size of the position error box in square degrees, defined as box 2 in NASA Technical Memorandum 79694, "New Hard X-Ray Sources Observed with HEAO-A2", Frank Marshall, etal., December 1978.

LIST - Name of list under which source was originally published

Comment 3 - 24 character comment field

The FORTRAN format for reading the data is: 1X,3A4,1X,4A4, 1X,4F10.3,2X,I5,1X,F5.1,2X,I2,1X,I8,1X,5AU,/,31X,4F10.3, 2X,F7.3,1X,A2,13X,5A4.

This catalog is maintained by GSFC personnel.

A.2 The SACC X-Ray Catalog

This catalog is maintained by CSC on the SACC system. It is present as a sequential file with the name, ZBARS.XRAY. CATALOG, and is cataloged on the system as well as archived under ASM2. Only sources with observed X-ray emission, 415 total, are present in this catalog. Each source present has a 52-byte logical record with the following data:

NAME: 12-character primary name(EBCDIC)

ALIAS: 12-character secondary name. For source positions were updated, the ALIAS reflects the change while the NAME is unchanged. (EBCDIC)

SPARE: 4-bytes unused

INTENSITY: observed x-ray rate in UHURU counts/second

ELON50:Ecliptic Longitude (Epoch 1950) in radians.

ELAT50:Ecliptic Latitude (Epoch 1950) in radians.

RA50: Celestial Right Ascension (Epoch 1950) in radians.

DEC50: Celestial Declination (Epoch 1950) in radians.

INTENSITY is a 4-byte Integer. All position variables are 4-byte, single precision, IBM floating point variables.

It should be noted that this catalog is designed for optimum use with the HEAO-A2 Data Processing System. Choices of format, units and position Epoch, as well as included sources, reflect that design goal.

APPENDIX B - FCUT DATA QUALITY TESTS

This appendix contains a brief summary of all the data quality tests used by program FCUT. The actual data selection tests are performed in routine SRCANL, using flags calculated by CLEAN, SPFLAG and NOMINL, as well as flags on the MAX data base.

The set of requirements for acceptable data is:

- No fill data in the major frame record.
- Experiment status does not change during the major frame
- Experiment status is in one of the defined nominal states.
- The spacecraft has a normal scan rate and spin axis position.
- The detector is unnocculted by the sphere defined by the earth with 200 km. of atmosphere.
- The detector has its High Voltage on and stable.
- For the LED's and MED, the source rod is out of the field of view.
- The calculated electron rate is within limits.
- The detector command status corresponds to one of the defined nominal states.

A detailed explanation of all these flags is given in the programmers document for program SKYMAP, CSC/TM-81/6123 "High Energy Astronomy Observatory -1 (HEAO-A2) Program SKYMAP Programmer's and Operator's Guide"

APPENDIX C - FCUT SOURCE SUMMARY TAPES

C.1 FCUT OUTPUT TAPE

This tape is the summary output of the FCUT source analysis package. It contains a file of data for each 12-hour period analyzed. Each file contains information on source intensity and variability as measured with the Discovery Scalers on a pass-by-pass basis, and also on a 12-hour basis.

Tape Structure: Each tape will contain results for up to about 200 days of data (1600 BPI) with one file for each 12 hours of data. Each file (see Figure 1) contains one record for each source visible during that 12-hour period and also records for the left and right side backgrounds determined for these source regions, as well as a header record which the time, the number of source regions fitted, and a list of sources for each region. These records are described in detail below.

C.1.1 File Header Record: 3473 bytes

The File Header record is arranged as represented by:

```
/HEADER/TITLE(8), IDAY1, MSEC1, IDAY2, MSEC2, NRECS
NREG, REGBEG(15), REGEND(15), HFRSTS(15), HLASTS(15),
SNAME(3,50), SRA(50), SDEC(50), NFILL(559)
```

where:

TITLE	R*4	Thirty-two character label(ECPIC)
IDAY1	I*4	Day number at start of analysis
MSEC1	I*4	Milliseconds of day at start of analysis
IDAY2	I*4	Day number at end of analysis
MSEC2	I*4	Milliseconds of day at end of analysis
NRECS	I*4	Number of records following this one in file
NREG	I*4	Number of region fits for a scan of data

REGBEG	R*4	For each region, the start scan angle (Deg.)
REGEND	R*4	For each region, the end scan angle (Deg.)
HFRSTS	I*2	For each region, the index in the following source list of the first source in the region
HLASTS	I*2	For each region, the index of the last source in the region
SNAME	R*4	A 12-character source name for each source
SRA	R*4	Source Right Ascension (1950, radians)
SDEC	R*4	Source Declination (1950, radians)
NFILL	I*4	Spare

Note: The source list increases monotonically with scan angle, with the first source in Region 1 being the first source in the list.

C.1.2 File Data Record: 3472 bytes

/SOURCE/SNAME(3), SRA, SDEC, NOCC, SCINT (2,4,4,25), ISTAB, VFRAC, HDAY(24), MSEC(24), SCAN(24)

where:

SNAME	R*4	A 12-character record title. Source name if source record.
SRA	R*4	Source Right Ascension and Declination
SDEC	R*4	Spare for Background record (1950,radians)
NOCC	I*4	Number of passes analyzed (may be 0)
SCINT	R*4	Source/Background intensities and errors as follows: SCINT(I,J,K,L): I-1 for intensity $(cm^2\text{-sec})^{-1}$ =2 for error J=1,4; D,S, pair index K=1,4; Detector index

		L=1,24: Pass index L=25; 12-hour results
ISTAB	I*4	First order temporal stability flag ISTAB=1 if pass-by-pass results have a χ^2 probability greater than 2 percent for constant source intensity
VFRAC	R*4	Normalized on axis variance ratio. VFRAC-1.0 for pure Poisson statistics. Set only for source zones where source contributes at least 1/2 the total rate, using method of E. H. Boldt.
HDAY	I*2	Day of each single pass
MSEC	I*4	Millisec of day of first MF in region pass
SCAN	R*4	Scan angle of y-axis at beginning of first MF

C.2 Sorted FCUT Source Data Tape

This set of tapes contains the source intensities as determined by FCUT for single passes and for 12 hour averages. The set of tapes contains one file for each source in the HEAO catalog, with the files in the same order as the catalog. There are approximately 90 files on each tape.

Each file contains all results for a given source, with records in order of increasing time of observation. Each record in the file contains the data for a 12 hour period of observation. The single pass results are stored in order, along with the approximate observation time (good to about 5 seconds). Two additional 12 hour quantities are also present, ISTAB, a crude stability flag, and VFRAC, a normalized variance function. To determine ISTAB, an approximate shisquare is calculated for constant rate using the 12 hour average as the constant, and the single pass intensities with their errors. If the corresponding probability is less than 1% for any detector, for the first two DS pairs combined, the flag is set.

VFRAC is the calculated ratio of the variance of the source rates to the average of the source counts as taken from equation 13 of the HEAO-A Technical Note in Appendix E.

$$\frac{\text{var}(N^0)}{<N^0>} = 1 + (\chi^2 - k) / \sum_{i=1}^{k} [\alpha_i/(1 + \beta/\alpha_i)]$$

For FCUT,

β is the fitted background divided by the fitted source rate in the sum of the first 4 Discovery scalers.

α_i is the Left + Right aspect fraction.

χ^2 is the calculated chisquare for the source zone.

VFRAC is claculated only using 80 msec, multiscaler data, and only using data when the fitted source rate is at least 50% of the total fitted rate.

The file data records are 3471 bytes long, and all have the same variables in binary format. The list of variables can be accessed as a FORTRAN common block using the SACC FREAD routines, eg.

```
/SOURCE/SNAME(3), SRA, SDEC, NOCC, SCINT(2,4,4,25),
ISTAB, VFRAC, HDAY(24), MSEC(24), SCAN(24)
```

with the variables defined in Table C-1.

TABLE C-1

Variable	Type	Definition
SNAME	R*4	A 12-character source name as on the catalog (IBM S/360).
SRA	R*4	Source Right Ascension (1950 radions).
SDEC	R*4	Source Declination (1950 radians).
NOCC	I*4	Number of passes analyzed.
SCINT	R*4	Source intensities and errors as follows: SCINT (I,J,K,L): I=1 for intensity $(cm^2 sec)^{-1}$ =2 for error squared J=1,4: Discovery scaler pair index, i.e., J=1 for DS1, DS2 K=1,4: Detector index, (HED1, HED2, MED, HED3) L=1,24: Pass index L=25: 12-hour results Uses Areas from Rothschild (1977)
ISTAB	I*4	First order temporal stability flag ISTAB-1 if pass-by-pass intensities have a χ^2 probability greater than 1 percent for being equal to the 12 hour average intensity.
VFRAC	R*4	Normalized on axis variance ratio. VFRAC-1.0 for pure Poisson statistics. Set only for source zones where source contributes at least 1/2 the total rate, using method of E.H. Boldt.
FDAY	I*2	Day of each single pass
MSEC	I*4	Seconds of day for observation of source.
SCAN	R*4	Scan angle of source. (Degrees)

APPENDIX D - GENERAL FITTING TECHNIQUES

D.1 METHOD OF PERFORMING MAXIMUM LIKELIHOOD ESTIMATE AMONG A SET OF FUNCTIONS

The probability of determining a function y given a set of functions f at data points x_i is

$$P(y|f') = \frac{\exp\left[1/2 \sum_{i=1}^{N} ((f_i' - y_i)/\sigma_i)^2\right]}{(2\pi)^{N/2} \prod_{i=1} \sigma_i} \tag{D-1}$$

where $f_i' = f'(\chi_i)$ set of functions at data point χ_i

$$y_i = f'(\chi_i) - \delta_i = c_1 f_1(\chi_i) + f_2(\chi_i)c_2 + \ldots\ldots\ldots + f_m(\chi_i)c_m - \delta_i \tag{D-2}$$

m = number of functions

n = number of data points

σ_i = standard deviation of y_i

To obtain maximum probability $p(y|f')$ one must minimize the exponent, or

$$s = \sum_{l=1}^{N} ((f_i' - y_i)/\sigma_i)^2 \tag{D-3}$$

If we assume that σ_i is constant then we must minimize

$$\sum_{i=1}^{N} \delta_i^2$$

where

$$\delta_i = \sum_{j=1}^{M} c_j f_j(\chi_i) - y_i \tag{D-4}$$

where

$$i=1,\ 2,\ \ldots,N$$

A necessary condition for $\sum \delta_i^2$ to be a minimum is that the partial derivative be zero,

$$\frac{\delta \sum_{i=1}^{N} \delta_i^2}{\delta c_k} = 0 \qquad k = 1,2,\ \ldots,n$$

(D-5)

or

$$\sum_{i=1}^{N} \delta_i \frac{\partial \delta_i}{\partial c_k} = 0$$

but

$$\frac{\partial \delta_i}{\partial c_k} = f_k\ (\chi_i)$$

from Equation (D-4).

Substituting this, and the value δ_i from Equation (D-4) we obtain

$$\sum_{i=1}^{N} \left[\sum_{j=1}^{m} c_j f_j(\chi_i) - y_i \right] f_k(\chi_i) = 0$$

or (D-6)

$$\sum_{j=1}^{m} c_j \sum_{i=1}^{N} f_j\ (\chi_i)\ f_k\ (\chi_i) = \sum_{i=1}^{N} y_i f_k(\chi_i) \qquad k=1,2,\ldots,m$$

This system consists of m unknown (c_1, c_2, ..., c_m) and m Equations. It can also be written in matrix notation as

$$\bar{A}\ \bar{c} = \bar{b} \qquad \text{(D-7)}$$

where

$$\bar{A} = [a_{jk}] = \left[\sum_{i=1}^{N} f_j(\chi_i) f_k(\chi_i)\right] \quad \text{symmetric matrix}$$

$$\begin{bmatrix} \sum_{i=1}^{N} f_1(\chi_i)f_1(\chi_i) & \sum_{i=1}^{N} f_1(\chi_i)f_2(\chi_i) & \cdots & \sum_{i=1}^{N} f_1(\chi_i)f_m(\chi_i) \\ \sum_{i=1}^{N} f_2(\chi_i)f_1(\chi_i) & \sum_{i=1}^{N} f_2(\chi_i)f_2(\chi_i) & \cdots & \sum_{i=1}^{N} f_2(\chi_i)fm(\chi_i) \\ \vdots & & & \\ \sum f_m(\chi_i)f_1(\chi_i) & \sum f_m(\chi_i)f_2(\chi_i) & \cdots & \sum f_m(\chi_i)f_m(\chi_i) \end{bmatrix}$$

It can be seen that $A = A^T$ where A^T is transpose of A

$$c = [c_j]$$

$$b = [b_j] = \left[\sum_{i=1}^{N} y_i f_j(\chi_i)\right]$$

D.2 METHOD OF COMPUTING STATISTICAL ERRORS

D.2.1.A Computing the Variance of Least Squares Fit

The variance of least squares fit σ_f^2 is defined as

$$\sigma_f^2 = \sum_{j=1}^{N}\left[y_j - \sum_{i=1}^{M} c_i f_i(\chi_j)\right]^2 /(N-M) \qquad \text{(D-8a)}$$

where
y_j = independent observed value
c_i = computed coefficients of least sqaures fit
$f_i(\chi_j)$ = observed function of data point χ_j
N = number of data points χ_j ($j = 1,2,\ldots,N$)
M = number of functions $f_i(\chi_j)$ at data point χ_j
σ_f = standard error of estimate

Equation (D-4) can be written in matrix form as

$$\sigma_f^2 = (y^T y - 2c^T F\ y + c^T F^T Fc)/(N-M) \qquad \text{(D-8b)}$$

where y = (N x 1) matrix of y_j's

y^T = the transpose of y matrix

c = (M x 1) matrix of c_i's

c^T = transpose of c matrix

F = (N x M) matrix of $f_i(\chi_j)$

F^T = transpose of F matrix

The variance of y_j's, σ_y^2 is given as

$$\sigma_y^2 = \left[\frac{\sum_{j=1}^{N} y_j^2}{N}\right] - \left[\frac{\sum_{j=1}^{N} y_j}{N}\right]^2 \qquad \text{(D-9)}$$

The σ_y is standard deviation which measures the scatter (variation) about the arithmetic mean, while σ_f (the standard error of estimate) measures the scatter about the least squares fit curve (or line).

D.2.2 Computing the Variance-Covariance Matrix of c_i's

It will be shown the $(F^T wF)^{-1}$ is the covariance matrix of c_i's. That is, the diagonal elements of this matrix represent the variance of c's and the off-diagonal elements represent the covariance of the c's.

where F = matrix of $f_i(\chi_j)$ (N x M)

F^T = transpose matrix of F (M x N)

W = diagonal weighing matrix of $\left[1/\sigma_y{}^2\right]$ (NxN)

Let

$$A = F^T W F \tag{D-10}$$

$$b = F^T W Y \tag{D-11}$$

such that

$$\bar{A} \bar{c} = \bar{b} \tag{D-12}$$

The covariance of the unknown coefficients can be written as

$$\text{cov } (c_i, c_j) = \int_{\infty}^{\infty} \int_{\infty}^{\infty} (u-k_i)(v-k_j) P_{c_i, c_j}(u,v)\,du\,dv$$

where c_i, c_j are the ith and jth "solved for" coefficients

P_{c_i,c_j} (u,v) probability function that c_i, c_j will acquire the value u and v, respectively.

k_i, k_j are the expected ("correct or mean") values of c_i and c_j respectively. They can be defined with the expected value function as

$$E(c_i) = \int_{\infty}^{\infty} u \, P(u) \, du$$

$$\text{The mean value of } c_i \text{ is } = \frac{\int_{\infty}^{\infty} u \, P(u) \, du}{\int_{\infty}^{\infty} P(u)\,du}$$

but $\int_{\infty}^{\infty} P(u)\,du = 1$ therefore mean $c_i = \int_{\infty}^{\infty} u \, P(u)\,du = k_i$

The cov (c_i, c_j) can also be written in term of the expected value functuon

$$\text{cov}(c_i, c_j) = E(c_i - k_i)(c_j - k_j)$$

This can be expanded by

$$E(c_i-k_i)(c_j-k_j) = E(c_ic_j-c_ik_j - c_jk_i + k_ik_j)$$
$$= E(c_ic_j) - k_j\ E(c_i)-k_i\ E(c_j) +k_ik_j$$

but $E(c_i) = k_i$ and $E(c_j) = k_j$

$$\text{cov}\ (c_i,c_j) = E(c_ic_j)-k_ik_j$$

This equation in matrix forms becomes

$$\text{cov} = E(c\ c^T)-k\ k^T$$

From Equation (A-12) $c = A^{-1}b$

$$E(c\ c^T) = E(A^{-1}b\ b^T(A^{-1})^T$$

then

$$E(c\ c^T) = E(A^{-1}b\ b^T\ A^{-1}) = A^{-1}\ E(b\ b^T)\ A^{-1}$$

To find $E(b\ b^T)$ use the elements of the matrices, i.e.

find $E\ (b_rb_s)$

where

$$b_r = \sum_{i=1}^{N} \frac{1}{\sigma_i^2}\ y_if_r(\chi_i)$$

$$b_s = \sum_{i=1}^{N} \frac{1}{\sigma_j^2}\ y_j\ \ f_s(\chi_j)$$

such that

$$E(b_r b_s) = \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{1}{\sigma_i^2} \quad \frac{1}{\sigma_j^2} f_r(\chi_i) f_s(\chi_j) E(y_i y_j)$$

Since y_i is independent of y_j $(i \neq j)$

$$\text{cov}(y_i, y_j) = 0 = E(y_i y_j) - E(y_i)E(y_j)$$

and when $i = j$

$$\text{cov}(y_i, y_j) = \text{var}(y_i) = \sigma_{y_i}^2 = E(y_i y_j) - E(y_i)E(y_j)$$

$$E(b_r b_s) = \sum_{i=1}^{N} \frac{1}{\sigma_i^2} f_r(\chi_i) E(y_i) \sum_{j=1}^{N} \frac{1}{\sigma_j^2} f_s(\chi_j) E(y_j) + \sum_{i=1}^{N} \frac{1}{\sigma_i^2} f_r(\chi_i) f_s(\chi_i)$$

Since $y = Fc$

$E(y) = E(Fc)$

$E(y) = FE(c)$

$E(y) = Fk$

An element is

$$E(y_i) = \sum_{q=1}^{N} f_q(\chi_i) k_q$$

Such that

$$E(b_r b_s) = \sum_{i=1}^{N} \frac{1}{\sigma_i^2} f_r(\chi_i) \sum_{q=1}^{N} f_q(\chi_i) k_q \sum_{j=1}^{N} \frac{1}{\sigma_j^2} f_s(\chi_j) \sum_{q=1}^{N} f_q(\chi_j) k_q$$

$$+ \sum_{j=1}^{N} \frac{1}{\sigma_i^2} f_r(\chi_i) \; f_s(\chi_i)$$

In matrix form this becomes

$$E(b\ b^T) = F^T\ w\ F\ k\ (F^T\ w\ F\ k)^T + F^T\ w\ F = A\ k\ k^T A^T + A$$

Since $(Ak)^T = k^T\ A^T$ and $A^T = A$ (symmetric matrix)

$$\begin{aligned} cov = {} & E(c\ c^T) - k\ k^T \\ & = A^{-1}(A\ k\ k^T\ A + A)\ A^{-1} - k\ k^T \\ & \quad k\ k^T + A^{-1} - k\ k^T \end{aligned}$$

$$cov = A^{-1} = (F^T\ wF)^{-1} \qquad \text{(D-13)}$$

The w weighing matrix can be defined a diagonal matrix where the elements are $\frac{1}{\sigma_i^2}$.

If one assumes that

$$\sigma_i = \sigma_f \qquad i=1,2,\ ...N$$

the covariance matrix becomes

$$cov = \sigma_f^2\ (F^T\ F)^{-1} \qquad \text{(D-14)}$$

APPENDIX E - A VARIANCE ANALYSIS GENERALIZED FOR A SCANNING EXPERIMENT

Consider a total count (N) arising from

a) Counts due to n_j equivalent uncorrelated events (of class "j"), and

b) a Poisson background count (P).

In general,

$$(1) \quad \frac{\mathrm{var}(N)}{N} = 1 + \sum_j f_j \left[\bar{M}_j + \frac{\mathrm{var}(M_j)}{\bar{M}_j} - 1\right]$$

Where M_j is the observed count per event (class "J"), viz:

$$(2a) \quad \sum_j n_j M_j = N - P = nM,$$

and the fraction of counts due to "events" of class "j" is given by

$$(2b) \quad f_j = \frac{n_j M_j}{(nM + P)}$$

$$(\text{with } n = \sum_j n_j)$$

For a scanning experiment, there is an aspect correction α ($\leq$ 1) such that

$$(3a) \quad M = \alpha M^0$$

$$(3b) \quad P = \alpha P_0 + P_B$$

where M^0 and P_0 give the on-axis valves for the <u>source</u> and P_B is the non-source background.

From Eq. 2 and Eq. 3 we obtain

$$(4) \quad f = \frac{\alpha f^0}{\alpha + \beta}$$

where β is the ratio of non-source background to on-axis source count, viz:

(5) $\beta = \dfrac{P_B}{nM^0 + P_0}$

and f^0 is the fraction of <u>source</u> counts due to "events" viz:

(6) $f^0 = \dfrac{nM^0}{nM^0 + P_0}$

For simple shot-noise, var $(M_j) = \bar{M}_j$.

However, to be more general, let's consider possible stochastic structure within events, as follows:

(7) $\dfrac{\text{var }(M_j)}{\bar{M}_j} = 1 + \varepsilon_j \bar{m}_j + ---$

where m_j $(=\alpha\bar{m}_j^0)$ is the average count per uncorrelated sub-event within the composite event of M_j counts, and ε_j is the fraction of the M_j counts due to such sub-events. Using Eq. 4 and Eq. 7 in Eq. 1 yields:

(8) $\text{var }(N) = \bar{N}\left[1 + \dfrac{\alpha\bar{M}^0_{\text{eff.}}}{1+ (\beta/\alpha)}\right]$

where $\bar{M}^0_{\text{eff.}}$, the expectation value for the on-axis "effective" count per event, is given by

(9) $\bar{M}^0_{\text{eff.}} = \sum\limits_j f_j^0 \, (\bar{M}_j^0 + \varepsilon_j \, \bar{m}_j^0)$.

We are now in a position to analyze data from a source transit. We model the expected count in bin "i", $\langle N_i\rangle$, on the assumption of a constant non-source background and a point source of constant intensity, at a known position. We then evaluate χ^2 for this model noting that, for the k bins sampled,

(10) $\chi^2 = \sum\limits_i^k \dfrac{\text{var }(N_i)}{\langle N_i\rangle}$

However, from Eq. 8 we obtain

$$(11) \quad \sum_{i}^{k} \frac{\mathrm{var}(N_i)}{N_i} = k + \bar{M}^0_{\mathrm{eff.}} \left[\sum_{i}^{k} \left\{ \frac{\alpha i}{1 + (\beta/\alpha_i)} \right\} \right]$$

For the source alone, on-axis, we note

$$(12) \quad \mathrm{var}(N^0) = \bar{N}^0 \quad 1 + \bar{M}^0_{\mathrm{eff.}}$$

(i.e., with $\beta=0$, $\alpha=1$ in Eq. 8).

In this way we obtain the equivalent variance for the source alone, on-axis; i.e. Eqs. 10-12 yield:

$$(13) \quad \mathrm{var}(N^0) = \langle N^0 \rangle \left[1 + \frac{\chi^2 - k}{\sum_{i}^{k} \left\{ \frac{\alpha i}{1 + (\beta/\alpha_i)} \right\}} \right]$$

where $\langle N^0 \rangle$ and β are obtained by fitting the idealized model, α is determined from aspect data via the detector collimator response function, and χ^2 is evaluated by comparing the k samples of counts obtained during a source transit with the model.

The temporal fluctuations of the source are studied by evaluating $\bar{M}^0_{\mathrm{eff.}}$ (via Eq. 12-13) as a function of bin sample time (Δt). For bin sample times short compared with any of the correlation times (i.e. "event" duration), $\bar{M}^0_{\mathrm{eff.}} \propto \Delta t$. On the other hand, for sample times long compared with the duration times of "events" (the classical situation for shot-noise) $\bar{M}^0_{\mathrm{eff.}}$ approaches a constant.

APPENDIX F - FCUT DIRECT ACCESS FILE

The FCUT Direct Access file is a scratch disk file accessed through the SACC FTIO utility routines DREAD, and DWRITE. It is used to store up the pass by pass results for source region background and source rates for use in the 12-hour analysis. It has 80 blocks of binary data each containing

IOCC, SCINT (2,4,4,24),

where

IOCC (I*4)	is the number of single passes saved in the block.
SCINT (I,J,K,L) (R*4)	is the fitted source rate or variance as follows:
I=1	for rate, I=2 for variance
J=	Discover Scaler pair index
K=	Detector index
L=	Pass index

Data is accessed using the block number.

At the beginning of each 12-hour period, a source or region background is associated with a given block in the following manner. The sources are located in blocks 1-50 starting with region 1 sources, in order of increasing scan angle. Each region has two blocks of background starting with region 1 in block numbers 51 and 52. The first block of region background is the left field of view background, the second is for the right field of view. At this time all blocks are filled with zeros by INIT2. The FCUT JCL allocates 40 tracks of disk space for this file, two blocks per track. The record format is fixed block (F) with block size 3,076 bytes. The space is deleted upon job completion.

CSC

COMPUTER SCIENCES CORPORATION

Major Offices and Facilities Throughout the World

HEAO-1

A-2 FCUT BACKGROUND DATABASE

77-075A-02Q

This data set consists of 1 tape. The tape is multifiled, 9-track, 1600 BPI, binary, and was created on an IBM computer. The D and C numbers with the time spans are as follows:

D#	C#	FILES	TIME SPAN
D-101455	C-032309	62	09/07/77 - 12/20/77

Award
77-075A-02Q.

CSC/TM-81/6218

HIGH ENERGY ASTRONOMICAL OBSERVATORY SATELLITE A-2 MULTI-PURPOSE ANALYSIS PROGRAM (FCUT-B) DESCRIPTION AND USER'S GUIDE

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

CONTRACT NAS 5-24350
Task Assignment 717

NOVEMBER 1981

CSC

COMPUTER SCIENCES CORPORATION

CSC/TM-81/6218

HIGH ENERGY ASTRONOMICAL OBSERVATORY SATELLITE A-2
MULTI-PURPOSE ANALYSIS PROGRAM (FCUT-B)
DESCRIPTION AND USER'S GUIDE

Prepared for
GODDARD SPACE FLIGHT CENTER

By
COMPUTER SCIENCES CORPORATION

Under

Contract No. NAS 5-24350
Task Assignment 717

Prepared by:

For A R Stottlemyer 12 Nov 81
Dr. D. Lengyel-Frey Date

Reviewed by:

A R Stottlemyer 12 Nov 81
Dr. A. Stottlemyer Date
Section Manager

Approved by:

Max D Silbergeld 11/13/81
M. Silbergeld Date
Department Manager

ABSTRACT

The Cosmic X-ray Experiment (A2) on board the first High Energy Astronomy Observatory (HEAO-1) satellite is designed to survey the emission of non-solar X-rays over the entire sky. The HEAO-2 data processing system provides computerized analysis and bulk data processing for this experiment at the Goddard Space Flight Center, (GSFC). The FCUT-B program analyzes the data to determine detector calibration constants, to search for x-ray background anisotropies, and to model the experimental background. This document describes the program software and operating procedures. In-code module documentation accompanies the source code which is filed at GSFC.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

LIST OF TABLES

Table

SECTION 1 - INTRODUCTION

Program FCUT performs various analyses of the HEAO-A2 MAX Production data base. The program discussed in this document is Build 2 of FCUT, FCUT-B, which performs the following four analyses: a) diffuse background; b) non-X-ray background; c) X-Ray anistropy; d) detector calibration. Any combination of these analyses can be performed during one FCUT-B run. To carry out each analysis, data is accumulated over intervals which are multiples of 12 hours. Typically, however, a run is made for 8 days of MAX data. Data from the four HEAO-A2 detectors, HED1, HED2, MED, and HED2, can be analyzed.

SECTION 2 - OVERVIEW

2.1 SYSTEM OVERVIEW

The HEAO-A2 data processing system is a multi-program system with program modules to perform separate tasks for quality control, for establishing convenient data bases and efficient analysis, and for performing some preliminary data analysis. The system is designed to perform as an off-line "Production" data analysis system. The system design incorporates the ability to process large quantities of data. Figure 2-1 illustrates the designed system flow. This entire system is designed for operation on the SACC IBM S/360-75 and S/360-91 computers at GSFC.

The data input to the system is received from GSFC's Information Processing Division (IPD) on magnetic tape in a previously defined format.[1] Production data is produced for all telemetry, and is available within 6 weeks of transmission. In addition to the experiment data tapes, a Command Summary tape is produced by Marshall Space Flight Center and delivered to the experimenters. This tape contains only a record of commands sent and acknowledged by the satellite. The X-ray Source Catalog, compiled by the A2 experimenters, incorporates all known X-ray sources as well as a large number of potential sources. The primary catalog is maintained by CSC as a disk file on a PDP-11/70 computer in GSFC's Laboratory for High Energy Astrophysics.

The first processing of received data is a series of detailed tests to evaluate data quality and experiment status, and to

[1] National Aeronautics and Space Administration, GSFC, X-565-77-60, Data Processing Requirements for High Energy Astronomy Observatory A (HEAO-A), H. Linder, June 1977.

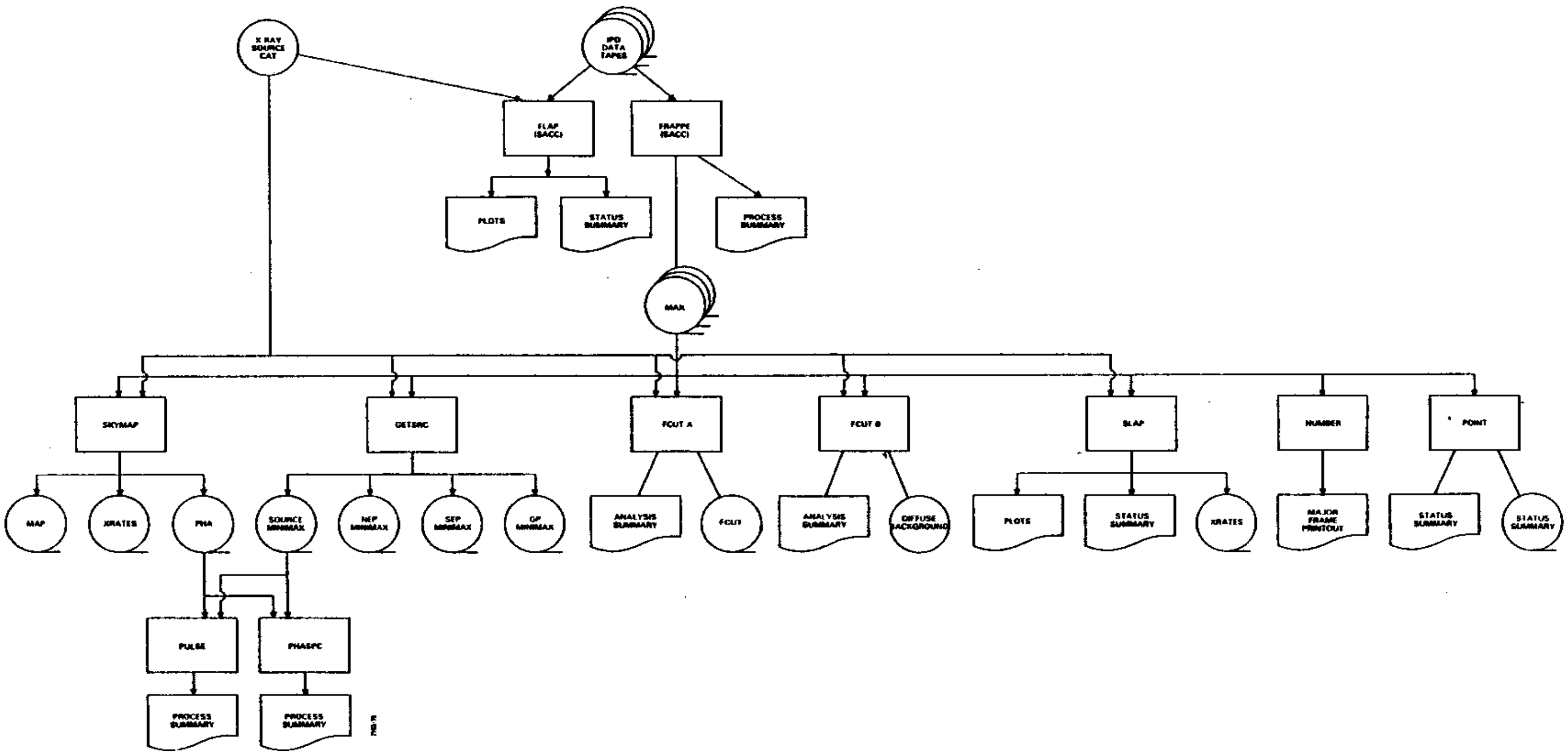


Figure 2-1. HEAO-A2 Data Processing System

display some of the raw data for preliminary analysis. These functions are combined into a single module, the First Look Analysis Program (FLAP), which is coded in FORTRAN and ALC (IBM assembly language).

The next data processing stage is the production of a restructured data base (MAX), which facilitates the data analysis. This is done by re-formatting the data into a FORTRAN-accessible format, re-ordering the data from telemetry stream order to accumulation time order, and setting up a series of data quality flags based on detector occultations, electron counting rates, and other quantities. The Frame Re-blocking and Production Processing Executive (FRAPPE) is the program which reads an IPD format tape and produces the MAX data base. Each file of the MAX data base normally contains 12 hours of data, with one file corresponding to a single spin axis position. Additional file marks are introduced when there are large gaps in the data.

A series of modules have been set up which use the MAX data base as input; these perform preliminary analysis functions and produce several condensed data bases.

Three modules that create condensed data bases are SKYMAP, GETSRC, and FCUT. SKYMAP is run on all Production data and creates up to three specialized data bases MAP, PHA, and XRATES. The first of these contains Discovery Scaler data averaged over time and ordered by the observed location of the sky. The second and third contain PHA data and Discovery Scaler data respectively, for major frames with good data. GETSRC extracts major frame records from the MAX tape whenever a selected location of the sky is being observed, and time orders these records on a separate output tape (MINI-MAX data base). GETSRC is used routinely to create data tapes for the North Ecliptic Pole, the South Ecliptic Pole, and the Galactic Equator. Special tapes for selected locations are created upon request.

There are two segments of the FCUT data analysis program which perform routine analysis of production data. FCUT B calculates detector energy calibration constants and compares them with expected values, calculates the X-ray background spectra and looks for large scale inhomogeneities, and performs a parameterization of the non-X-ray background. FCUT A searches for new point sources, performs a detailed analysis of the rates of known X-ray sources, and forms a data base containing these results.

A fourth module that uses the MAX data base to create a condensed data base is available, but not used on a routine basis.

The Second Look Analysis Program (SLAP) generates a complete, detailed experiment status report, a complete set of detector counting rate plots, and the XRATES data base mentioned above. The plots are designed to facilitate observation of detector problems, X-ray sources, and other phenomena of interest.

Program NUMBER is designed to produce a very detailed output from analysis of limited segments of data. It examines the data on a major frame basis, and generates line-printer information including scaler counting rates, pulse height analysis, and temporal data. Approximately six pages of information is output for each major frame; this includes raw data and output from the data analysis.

Program POINT produces a summary of detector digital status during all HEAO points at sources. Inputs to the program are the MAX data base, the TRW pointing list, a compilation of point times, and coordinates based on TRW data. For each run, a printout is generated giving both TRW information and actual point coordinates and times; a separate printout is produced for digital status changes during points. An output tape is written to allow later copies of the digital status reports.

The XRATES, MAP, PHA, and FCUT data bases are designed to allow their use with mini-computers, while the MINI-MAX data will normally be limited to large computers due to physical record size. Detailed analysis programs generally use these specialized data bases as input.

Two of these analysis programs are PHASPC and PULSE. PHASPC acculalates PHA and Discovery Scaler data for sources and background regions; PULSE is similar to PHASPC but has the added capability of dividing a pulse cycle into a number of segments and accumulating data for each segment separately. These programs use either the PHA or GETSRC data base as input and are run by the scientists for selected time intervals and sources.

2.2 PROGRAM OVERVIEW

2.2.1 General Overview

Program FCUT-B (Background Analysis) performs an accumulation and analysis of Pulse Height Analysed (PHA) and/or Discovery Scaler (DS) data, depending on which analysis segments are chosen. The data is accumulated for chosen time intervals for each analysis module (always multiples of 12 hours). Since not all PHA data is compatible for accumulation (e.g., data of different PHA channel compressions or PHA channel limits), a specific memory format, and C45 and C46 switch-states are chosen for those analyses using PHA data.

The data-handling routines in the program are designed to read in MAX tape data on a major frame basis (40.96 sec of data). Except for the calibration analysis, super-super clean data is used in the analysis segments (see Appendix A for a definition). To pick out those major frames which have no sources in the detector field of view, a set of known x-ray sources within 4° of the nominal scan plane is extracted from the HEAO-A2 source catalog for each 12-hour nominal spin-axis setting. This list is used to calculate whether or not any are in the field-of-view of a detector during each major frame of data.

Only data in one of the standard memory formats may be accepted by the program. The standard formats are ROM1, ROM2, RAM1, RAM9, and RAM10. However, ROM2 data is not acceptable for the diffuse background analysis since no PHA data occurs in ROM2. For details about the memory formats, see the documentation on Program FRAPPE.[2]

The data of each MF is tested to determine if it is super-super clean. This means the data must be both clean and super-clean, in addition to passing other criteria. (See Appendix A for the definition of clean, super-clean, and super-super clean data).

Normally, only scan mode data is accepted for all but the calibration analysis. Scan data is defined as that received when the spacecraft has the nominal spin rate of 25 to 45 minutes per revolution, and has the spin axis within 2° of the current nominal Sun position. In some special cases (dead sky points, where the detectors are pointing at a known source-free region of the sky), point mode data may be accepted, if chosen.

In addition, to be acceptable the data must be in "nominal" mode (see Appendix B for this definition), be in the correct

[2] Computer Sciences Corporation, CSC/TM-79/6231, High Energy Astronomy Observatory Satellite-A (HEAO-A2) FRAPPE Program Description and Operator's Guide, A.K. Tolbert, September 1979.

memory format, and have the correct C flags (C27, C28, C45, C46) for the particular analysis being done. The correct flags are those which either are chosen by the user in the input NAMELIST or are the default parameters (i.e., those occurring in the first acceptable major frame in the data).

After the status of each major frame has been determined, as discussed above, a routine for each of the four types of analysis may be called to accumulate the major frame (MF) data for that analysis. These routines ascertain whether the MF data is acceptable for accumulation according to the criteria for each module; if so, the data is added in to accumulation arrays for later analysis.

If all data for the chosen time intervals has been read in, or if the program is nearing run time limits, the data in each chosen segment is analyzed. Results are obtained and printed. In some cases, results can also be saved via tape or cards.

The next sections describe the methods used in each analysis module.

2.2.2 Data Analysis Methods

2.2.2.1 Diffuse Background Analysis

This FCUT-B module performs an analysis of the diffuse X-ray background using super-super clean PHA and DS data. A portion of this analysis involves computing DS averages, variances, and errors for large field-of-view (LFOV) minus small field-of-view (SFOV) data, for the three HED and the one MED data, and for layer 1 and 2 separately. In this case, the averages are on a major frame basis. The DS variance is a measure of the homogeneity of the diffuse background. The fields-of-view are subtracted to delete the effects of internal background noise from the data. It is also possible to correct the data for non-x-ray background counts found by the non-x-ray analysis segment of the program, although these results must be carefully interpreted.

The Poisson variance for this data is computed so that it can be compared to the calculated "true" variance of the data to ascertain how well the data obeys Poisson statistics and to detect possible systematic errors in the data.

Data for each channel and combined layers of the PHA data are used to compute the (LFOV-SFOV) average and standard deviation per major frame for each channel.

A model of the diffuse background sky has been computed for each channel. Calculations include a ratio of observed to model data, the error in the ratio, the chi-square calculation (number of channels used), and the chi-square probability that the data is consistent with a constant ratio model.

The purpose of this study is to flag any time periods for which spectral anomalies occur in the diffuse background.

The above computations of the diffuse background analysis are done separately for data with the North Ecliptic Pole in (NEP) and not in ($\overline{\text{NEP}}$) the detector field-of-view, and also separately for the satellite on the sunlit and on the dark sides of the earth. The results are therefore obtained for $\overline{\text{NEP}}$/dark, $\overline{\text{NEP}}$/sun, NEP/dark, and NEP/sun data.

The last portion of this analysis is a comparison of the above four kinds of data. Specifically, $\overline{\text{NEP}}$/dark is compared to NEP/dark, $\overline{\text{NEP}}$/sun to NEP/sun, $\overline{\text{NEP}}$/sun to $\overline{\text{NEP}}$/dark and NEP/sun to NEP/dark. To do this, chi square and chi square probability computations are made on the assumption that for each channel the data of the first PHA array equals the comparison PHA array normalized to the first array by the ratio of DS averages for the arrays.

There is an option to calculate a weighted DS average of the two arrays being compared, where the DS data is for separate layers and the weighting factors used are the previously computed errors on the DS averages.

The equations used in the analysis will now be discussed.

Discovery Scaler Results:

The following calculations using DS data are for separate layers for each of the four detectors (HEDs and MED) and for each NEP array, where N is the number of major frames accumulated for each detector and each NEP array.

The DS average per MF is given by

$$\overline{\Delta X} = \sum_{i=1}^{N} \frac{X_i(\mathrm{LFOV}) - X_i(\mathrm{SFOV})}{N} = \sum_{i=1}^{N} \frac{\Delta X_i}{N}$$

where X_i is the total DS counts for the field-of-view for major frame i.

The DS "true" variance is

$$\sigma_t^2 = \sum_{i=1}^{N} \frac{(\Delta X_i - \overline{\Delta X})^2}{N}$$

The square of the error on the DS average is given by

$$\bar{\sigma}^2 = \sigma_t^2/N$$

and the Poisson variance is expressed by

$$\sigma_p^2 = \sum_{i=1}^{N} \frac{(X_i(\mathrm{LFOV}) + X_i(\mathrm{SFOV}))}{N} .$$

Finally the expression for the weighted DS average of NEP arrays for each layer is

$$\frac{\overline{\Delta X}\ (NEP_1) \cdot \overline{\sigma}^2\ (NEP_2) + \overline{\Delta X}\ (NEP_2) \cdot \overline{\sigma}^2\ (NEP_1)}{\overline{\sigma}^2\ (NEP_1) + \overline{\sigma}^2\ (NEP_2)}$$

where NEP_1 and NEP_2 are comparison NEP arrays.

The option is available for computing a non-X-ray background correction F_r to the DS data such that $F_r \Delta X$ observed is the corrected diffuse background data. If the option is not chosen, $\overline{F_r}$ defaults to 1. The factor $\overline{F_r}$ is given by

$$\overline{F_r} = \frac{\Delta C}{\overline{\Delta X}} ,$$

where ΔC is $C_1(LFOV)-C_1(SFOV)$, the first coefficient computed in the non-X-Ray background analysis. This coefficient is a model of the total background (internal and external diffuse background).

PHA Calculations:

The following calculations are for combined layers and separate NEP arrays, where N is the number of major frames accumulated.

The average counts per major frame is given by

$$\overline{\Delta X}_j = \sum_{i=1}^{N} \frac{\Delta X_{j_i}}{N}$$

where ΔX_{j_i} is LFOV-SFOV counts for channel J and major frame i. The error (standard deviation) is

$$\sigma_{J_t} = \left[\sum_{i=1}^{N} \frac{(\Delta X_{J_i} - \overline{\Delta X}_J)^2}{N} \right]^{1/2}$$

The error in the ratio to the model is expressed by

$$\sigma_{J_t} / \Delta X_{J\ \text{model}}$$

The chi square for a constant ratio model is

$$\chi_c^2 = \sum_J \frac{(R_J - \overline{R})^2}{\sigma_J^2}$$

where R_J = the ratio of observed to model counts and $\overline{R}$ is the average ratio per channel. In addition

$$\chi \sigma_J^2 = \frac{\sigma_{pj}^2 / N}{\Delta X_{j\ \text{model}}^2}$$

and σ_{pj}^2 is the Poisson variance.

The χ^2 for a model of an NEP array having the same spectral shape as a comparison array is

$$\chi_s^2 = \sum_j \frac{(\overline{\Delta X}_{j_1} - (\overline{\Delta X}_1/\overline{\Delta X}_2)\overline{\Delta X}_{j_2})^2}{\sigma^2_{j_{p_1}} \quad N_{1/N_2}}$$

where subscripts 1 and 2 refer to the two NEP arrays, and $\overline{\Delta X}_1$ and $\overline{\Delta X}_2$ are DS averages for the arrays.

2.2.2.2 Non-X-Ray Background Analysis

In the non-x-ray analysis the observed 5.12-sec DS rates are fit to a 16-parameter model of the x-ray background, including true x-ray and non-x-ray events. A least squares fitting procedure is used based on a maximum likelihood method.

It can be shown that to obtain the coefficients c_1 through c_m in the equation

$$Y_i = c_1 f_1(X_i) + c_2 f_2(X_i) + \ldots + c_m f_m(X_i)$$

where y_i is observed data for point i and the f_j's are the parameters of the model being fit, one solves for coefficients c in the equation

$$\sum_{y=1}^{m} c_{y} \sum_{i=1}^{N} f_y(X_i) f_k(X_i) = \sum_{i=1}^{N} y_i f_k(X_i) \qquad k = 1,2,\ldots m,$$

points. This can be written in matrix notation as

$$\underline{\underline{A}}\ \underline{\underline{c}} = \underline{\underline{b}}$$

where the components of symmetric matrix $\bar{\bar{A}}$ are

$$a_{jk} = \sum_{i=1}^{N} f_j(X_i) f_k(X_i) \quad ,$$

with σ_i^2 the error on the observed data point i.
$\bar{\bar{C}}$ is the linear coefficient matrix and the components of $\bar{\bar{b}}$ are

$$b_j = \sum_{i=1}^{N} Y_i f_j(X_i)$$

To obtain the coefficient matrix $\bar{\bar{c}}$, the matrix equation

$$c_j = \sum_{k=1}^{m} \left[a_{jk}\right]^{-1} \left[b_k\right]$$

is used, where the symmetric matrix $\bar{\bar{A}}$ is inverted.

The model chosen for the analysis is the following:

$$Y = Z + (B\ \bar{U}_b + \bar{U}).\bar{Q} + L\ (\alpha + \bar{V}_L.\bar{P}_1) + \bar{V}_1.\bar{P}_1 +$$

$$+ \bar{V}.(\Sigma\ I_n \bar{P}_n) + \bar{W}.\bar{S} + \bar{Y}.\bar{T}$$

where the barred variables are vectors.

The equation is evaluated for each 5.12-sec DS rate separately for layers 1 and 2 for large and small fields-of-view. The variable definitions are as follows:

Y	=	observed DS rates
Z	=	external and internal background counts = C_1
B	=	magnetic field strength
$\bar{U}_b$	=	$C_2\ \hat{X} + C_3\ \hat{Y}$
$\bar{U}$	=	$C_4 \hat{X} + C_5\ \hat{Y}$
$\bar{Q}$	=	$\sin\beta\ \hat{X} + \lvert\cos\beta\rvert\ y$ where β is the angle between the spacecraft Y-axis and magnetic field

$$L = \text{McIllwain parameter}$$

$$\alpha = C_6$$

$$P_1 = |\sin\phi_1 \sin\theta_1|\hat{X} + |\cos\phi_1 \sin\theta_1|\hat{Y}$$

where ϕ_1 and θ_1 are angles from the spacecraft to the center of the earth in spacecraft coordinates.

$$\bar{V}_L = C_7\hat{X} + C_8\hat{Y}$$

$$\bar{V}_1 = C_9\hat{X} + C_{10}\hat{Y}$$

$$\bar{V} = C_{11}\hat{X} + C_{12}\hat{Y}$$

$$I_n = \text{source intensity for source } n$$

$$\bar{P}_n = |\sin\phi_n \sin\theta_n|\hat{X} + |\cos\phi_n \sin\theta_n|\hat{Y}$$

where ϕ_n and θ_n are angles between the spacecraft and source n

$$\bar{W} = C_{13}\hat{X} + C_{14}\hat{Y}$$

$$\bar{S} = \sin(2\pi\delta/\lambda)\hat{X} + \cos(2\pi\delta/\lambda)\hat{Y}$$

where δ = spacecraft latitude

λ = orbital inclination

$$\bar{Y} = C_{15}\hat{X} + C_{16}\hat{Y}$$

$$\bar{T} = \sin(2\pi t/\tau)\hat{X} + \cos(2\pi t/\tau)\hat{Y}$$

t = time in GMT

τ = 24 hours

To form the arrays needed for solving for the C coefficients, super-super clean DS rates are accumulated. All of the 16 parameters are computed for each MF and accumulated as needed to form the $[a_{jk}]$ and $[b_j]$ matrix components.

After all MFs have been read in, the $\bar{\bar{A}}$ matrix is inverted to give the covariance matrix $\bar{\bar{A}}^{-1}$. The 16 coefficients are computed and errors for each found from

$$\sigma_{cj}^2 = [a_{jj}^{-1}].$$

The variance of the least squares fit σ_f^2 is computed from

$$\sigma_f^2 = \left(\sum_{i=1}^{N} Y_i^2 - 2\sum_{j=1}^{16} C_j[b_j] + \sum_{k=1}^{16}\sum_{j=1}^{16} c_j c_k[a_{jk}]\right)/N_d$$

Here N_d is the number of degrees of freedom N-16, where N is the number of MFs accumulated.

Also computed are the average DS rate $\sum_{i=1}^{N} Y_i/N = \overline{Y}$,

the variance about the mean

$$\sigma_m^2 = \Sigma Y_i^2/N - \overline{Y}^2,$$

and the χ^2 for the variance about the mean, approximately by

$$\chi_m^2 = \sigma_m^2 N/\sigma_p^2$$

where σ_p^2, the square of the Poisson error, is $\overline{Y}/8$. The denominator results from eight 5.12-sec DS rates averaged over each major frame and then accumulated and used to form the arrays.

Finally, the variance of the least squares fit σ_f^2 is used to compute the χ^2 for the fit, given by

$$\chi_f^2 = \sigma_f^2 N_d/\sigma_p^2$$

χ^2 probabilities for both the variance about the mean and variance of the fit are also found.

2.2.2.3 X-Ray Anisotropy

This module in the FCUT program is designed to investigate whether preferred directions exist in the x-ray background. Super-super clean data is accumulated if the spacecraft Y axis has galactic longitude lying between 160 and 200 degrees and if galactic latitude is less than -60 degrees or greater than 25 degrees. For other galactic longitudes, data is accepted if latitude is greater than 25 or less than -25 degrees. The data accumulated is LFOV-SFOV 5.12-sec Discovery Scalers using DS 1-8 for the HEDs and the MED.

A least squares fit is performed using the parameterization

$$\Delta X = c_o + c_1 \cos\theta + c_2 \sin\theta + c_3 \cos 2\theta + c_4 \sin 2\theta$$

to determine the coefficients c_j where θ is the angle between the detector axis and the North Ecliptic Pole at the midpoint of the DS 5.12-sec accumulation and ΔX is the 5.12-sec LFOV-SFOV counts averaged over the major frame.

For the analysis the following sums are formed:

$$a_{jk} = \sum_{i=1}^{N} f_j(\Delta X_i) f_k(\Delta X_i)$$

and

$$b_j = \sum_{i=1}^{N} \Delta X_i f_j(\Delta X_i)$$

where the ΔX_i are the 5.12-sec DS LFOV-SFOV differences, where the 5.12-sec rates are averaged for each major frame.

The parameters f_j are

$$f_o = 1$$

$$f_1 = \cos\theta_i$$

$$f_2 = \sin\theta_i$$

$$f_3 = \cos 2\theta_i$$

$$f_4 = \sin 2\theta_i$$

As for the non-x-ray analysis, the $\bar{\bar{A}}$ matrix is inverted and the coefficients found from

$$c_j = \sum_{k=1}^{m} a_{jk}^{-1} b_k \qquad \text{where } m=5 \text{ and } j=0,1,\ldots 4.$$

Also calculated are the mean 5.12-sec rate $\overline{\Delta X}$ averaged over all major frames, the variance from the mean, and the Poisson variances, given by

$$\sigma_t^2 = \sum_{i=1}^{N} \Delta X_i^2/N - \overline{\Delta X}^2$$

and

$$\sigma_p^2 = \sum_{i=1}^{N} (X_i(\text{LFOV}) + X_i(\text{SFOV}))/8N$$

where N is the total number of major frames accumulated in this analysis and X_i are the 5.12-sec rates averaged over major frame i for each field-of-view.

The χ^2 for a constant rate is found from

$$\chi^2 = \sigma_t^2 \, N/\sigma_p^2$$

Finally, the following parameters are computed and printed:

$$\begin{aligned}
A0 &= C_0 \\
X1 &= 100\ C_1/C_0 \\
Y1 &= 100\ C_2/C_0 \\
X2 &= 100\ C_3/C_0 \\
Y2 &= 100\ C_4/C_0 \\
A1 &= 100\ (C_1^2 + C_2^2)^{1/2}/C_0 \\
A2 &= 100\ (C_3^2 + C_4^2)^{1/2}/C_0 \\
P1 &= \tan^{-1}\ (C_2/C_1) \\
P2 &= \tan^{-1}\ (C_4/C_3)
\end{aligned}$$

Parameters X1, Y1, X2, and Y2 compare the magnitudes of the coefficients as an indication of which terms are important, A1 and A2 indicate the relative importance of the θ and 2θ terms, and P1 and P2 relate the coefficients to each other in magnitude and sign.

Errors for each of the parameters are also computed, using for the error on each coefficient

$$\sigma_{c_j} = [a_{jj}^{-1}]^{1/2}$$

where a_{jj}^{-1} is the jth diagonal element of the covariance matrix, and assuming no error on C_0 in the ratios.

2.2.2.4 Calibration Analysis

Calibration words from clean major frames are accumulated and the resulting histograms are used to find the peak channel which corresponds to the energy of the calibration line.

The original calibration data on board the satellite is composed of counts in 128 uncompressed energy channels, but this is transmitted in a compressed form using a 64-channel format. For each compressed channel, the corresponding mean uncompressed channel X_i is used to fit the data using a least squares fit to

$$y_i = e^{(b_o+b_1X_i+b_2X_i^2)}$$

where y_i represents the counts per uncompressed channel.

The assumed line shape is a Gaussian given by

$$Y_i = \frac{N}{\sqrt{2\pi}\sigma} e^{\left[-1/2\left(\frac{X_i-\mu}{\sigma}\right)^2\right]}$$

So solution of the equation for the b coefficients defines the parameters of the Gaussian line, namely the standard deviation

$$\sigma = (-1/2b_2)^{1/2},$$

the mean channel

$$\mu = b_{1/2b_2},$$

the number of counts in the line

$$N = \sqrt{2\pi}\ \sigma\ e^{(b_0+\mu^2/2\sigma^2)},$$

and the error on the mean channel

$$\sigma_{\mu} = \sigma/\sqrt{N}$$

HED Calibration:

For the HEDs, data is fit to either the 59.57-keV or 29.08-keV calibration line. The 59-keV line is used unless the line is unacceptable according to the following conditions.

If the channel with the largest number of counts between compressed channels 54-63 has at least 1/6 the counts of the peak channel in the range of 41.51, and if the counts in channel 63 are less than 3/4 of the peak channel in the 54-63 range, then the data corresponding to the 59 keV line is used for the fit. In this case, all channels contiguous to the peak channel and having more than 1/4 of the peak counts, excluding channel 64, are used.

If the 59-keV line is not acceptable according to the above requirements, then data from the 29-keV line is used. The peak channel in the range 40-50 in compressed channels is found, and all contiguous channels with at least 1/4 of the peak channel counts are used for the fit.

The HED calibration data for a MF must have C28=0 and the alpha threshold off. Data for only one C27 mode (0 or 1) will be accepted, the mode being either the first setting on the input tape or the mode chosen by the user.

MED Calibration:

For the MED detector only the 5.959-keV calibration line can be used for the Gaussian fit. The peak channel in the compressed channel range 31-46 is found and contiguous bins with at least 1/4 of the peak counts are accepted for analysis, out to a maximum of ± 8 uncompressed channels from the peak. The counts in each uncompressed channel are divided by the number of uncompressed channels comprising the compressed channel.

For the accumulation of calibration words, the data must have C28=1 and the alpha threshold on, and may be in either mode of C27. Only the 00 (or V2) ID mode data is accumulated and fit.

If the calibration source rod is in the MED field-of-view during a MF, PHA data is accumulated in a separate data array. This data is also fit to a Gaussain function in the manner just discussed. However, for this analysis, data can have any C28 or alpha threshold mode. For C27=0 the data must have C45=0 and C46=1 or 0. For C27=1, C46 must be 0. For this analysis, the peak channel is found between compressed channels 16 to 24 for the 32 channel-mode and between 31 to 46 for the 64 channel-mode.

For the calibration analysis, if X counts are in channel n this indicates that x counts occur in the bin between channel n and n+1, where compressed channels range between 1 and 64 and uncompressed channels span 1 to 128.

2.3 PROGRAM DESIGN

2.3.1 General Routine Design

Initialized COMMON block data for program FCUT-B is put in block data routines BLKDATFC and FCDATA. The MAIN routine calls subroutine INIT to initialize certain data and read input parameters from NAMELIST FCUT, which contains the input tape volume number, start file, interval start and end times, time interval chosen for each analysis, chosen modes (C27, C45, C46, etc.), if desired, for each analysis and detector, and print and punch option for some analyses. MAIN also mounts and positions the MAX input tapes through FTIO routines MOUNT and POSN and reads in the major frame records using FREAD. For each MF routine DIGIT, PROG1, CLEAN, and PROG2 are called. DIGIT saves the digital status for the three detectors having the digital status output during the MF. PROG1, through a call to ESRCES, sets up a catalogue of X-ray sources which lie within ±4.3° of the scan plane defined by the current spin axis of the satellite. A new catalogue is defined whenever a new MF has a spin axis more than 0.75 degrees different from that used to define the previous catalogue. PROG1 stores the current MF into COMMON block CURREC.

Subroutine CLEAN is called to ascertain whether data for a detector is clean in the current MF according to the definition in Appendix A. This routine also sets the digital status flag which indicates whether the DPU status, digital status or memory format have changed between the current and previous MF having status for a detector.

The main function of PROG2 is to call other routines necessary for determing data quality and accumulation data for the MF. This includes MFOV, which ascertains whether the moon is in the field-of-view of any detector, SCLEAN, which finds which detectors have super clean data, and SUPSUP for setting detector flags for super-super clean data. MODEC determines the C flags (C45, 46, etc.) for the three detectors with status output this MF and uses the C flags from the previous frame for the other three detectors. NOMINL determines whether a detector is in "nominal mode" during the MF. Detector data will not be accumulated for most analyses since it will not be considered super-super clean, if the mode is not nominal for both PHA and DS data. A definition of nominal mode, super clean and super-super clean data is given in Appendix A.

To be super-super clean, there can be no sources in a detector field-of-view (FOV) during a MF. To check this, SUPSUP calls SINFOV, which for each source in the current spin axis source catalogue calls SRCLOC. This routine first performs two crude tests to check that the source is within 4 degrees of the scan plane for the current MF and within 20 degrees of either the first or last Y-axis position of the MF. If the source passes these tests, then the source position is checked to determine if it falls within an accurately determined detector FOV during the MF.

SUPSUP also checks that the satellite is in normal scan mode during the MF. For this to be the case, the spin rate must be within acceptable limits and the satellite spin axis must be within 2° of the Sun. These tests are made in SPFLAG. The current Sun position is computed in SUNMUN using the Julian Day number derived in EPHEM.

PROG2 also calls the analysis routines COMCAL, DBIANI, NXRMOD and DBSPEC which accumulate data for the various analysis modules. If not enough CPU or I/O time is left for accumulating data during the chosen interval, as indicated by subroutine REMTIM, then SUMOUT is called to analyze the accumulated data.

MAIN calls SUMOUT at the end of each tape file or volume. SUMOUT checks the time interval chosen for each analysis and, if enough time has elapsed since the first MF was read in, the accumulated data is analyzed by calling the appropriate analysis module. The subroutines which are the drivers of the analysis are DBSPAN, NXRSTA, DBICOW and CALCON for the diffuse background, non x-ray, anisotropy and calibration analysis, respectively.

The run ends when either an end-of-tape volume is encountered and there are no more NAMELIST cards to be read, or when the MF time is after the time specified by IDAY2 and ITIM2, if set. In this event, SUMOUT is not called.

General coordinate transformation subroutines CVXYZ, CONVEC, UNITV, DOT, and CROSS are also used extensively throughout the program to perform vector manipulations for computing spacecraft coordinates. CVXYZ converts the spherical right ascension and declination coordinates of a vector into its Cartesian (X,Y,Z) coordinates. CONVEC, using calls to UNITV, DOT, and CROSS, converts any vector from celestial Cartesian coordinates to Cartesian spacecraft coordinates. UNITV computes the unit vector of a given 3-dimensional vector. DOT forms the dot product of two 3-dimensional vectors. CROSS computes the cross product of two vectors expressed in Cartesian coordinates.

The overall program structure is shown in the Hierarchy Diagram (Figure 2-2), with the modules keyed to the HIPO Table of Contents (Table 2-1). Additional cross-referencing information is given by the Cross-Reference Chart (Figure 2-3) and the Common Block Access Chart (Figure 2-4).

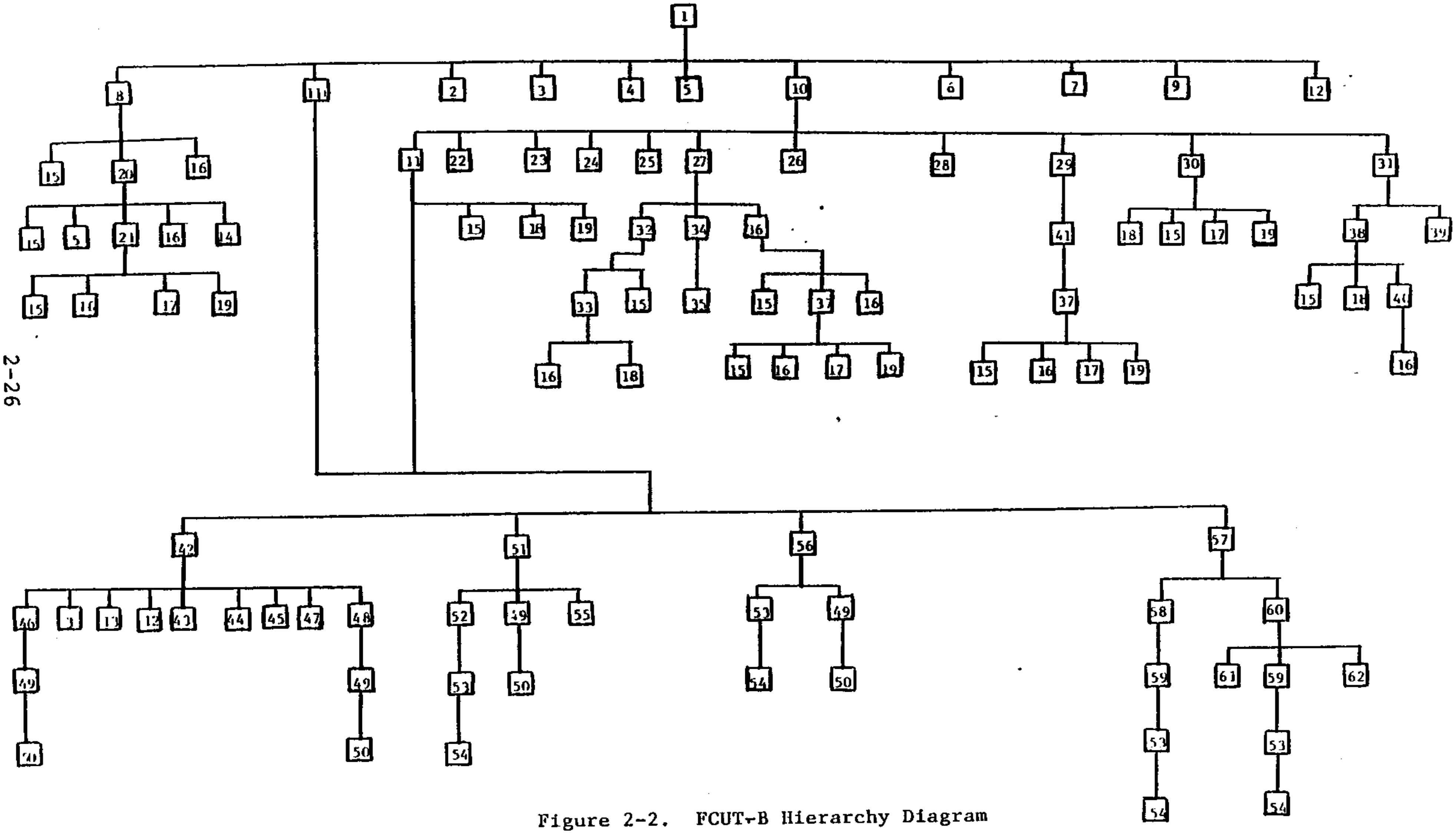


Figure 2-2. FCUT-B Hierarchy Diagram

Table 2-1. HIPO Table of Contents

1.	MAIN:	Handles overall control of processing.
2.	INIT:	Initializes run parameters.
3.	MOUNT:	Mounts a tape volume. FTIO library routine.
4.	POSN:	Positions tape to file mark. FTIO library routine.
5.	FREAD:	Reads a logical record. FTIO library routine.
6.	HEADER:	Writes header information on output tape and printer.
7.	DIGIT:	Calculates data quality flags from digital status.
8.	PROG1:	Moves current record into major frame (MF) COMMON block. Sets up new current source catalogue if needed.
9.	CLEAN:	Calculates whether detector data is clean.
10.	PROG2:	Controls processing of major frame data; calls data accumulation subroutines.
11.	SUMOUT:	Calls routines to analyze accumulated data if chosen interval times have elapsed.
12.	UNLOAD:	Unloads a tape volume. FTIO library routine.
13.	FWRITE:	Writes a record onto tape. FTIO library routine.
14.	REWIND:	Rewinds a tape or disk unit. FTIO library routine.
15.	CVXYZ:	Defines a vector in retangular celestial coordinates. Vector utility routine.
16.	DOT:	Calculates vector dot product. Vector utility routine.
17.	CROSS:	Calculates vector cross product. Vector utility routine.
18.	CONVEC:	Transforms vector into spacecraft coordinates. Vector utility routine.
19.	UNITV:	Calculates unit vector corresponding to input vector. Vector utility routine.
20.	ESRCES:	Determines list of x-ray sources in scan plane for current spin axis position.
21.	SCANGL:	Calculates ecliptic scan angle from celestial coordinates.
22.	REMTIM:	Computes CPU and I/O time remaining for run.

Table 2-1. HIPO Table of Contents (2 of 3)

23.	MFOV:	Sets flag if Moon in detector field-of-view for MF.
24.	SCLEAN:	Sets flags for detectors having super-clean data for MF.
25.	MODEC:	Computes C flags for detectors for MF.
26.	NOMINL:	Sets flags if detectors are in nominal mode for MF.
27.	SUPSUP:	Sets flags for detectors having super-super clean data for MF.
28.	COMCAL:	Accumulates data for calibration analysis.
29.	DBIANI:	Accumulates data for anisotropy analysis.
30.	NXRMOD:	Accumulates data for non-x-ray analysis.
31.	DBSPEC:	Accumulates data for diffuse background analysis.
32.	SINFOV:	Transforms satellite attitudes in preparation for source in field-of-view determination.
33.	SRCLOC:	Determines if any source in current source catalogue is in detector field-of-view.
34.	EPHEM:	Computes current Julian Day number.
35.	SUNMUN:	Computes current celestial coordinates of the sun.
36.	SPFLAG:	Tests whether satellite is in scan mode during the MF.
37.	SCANGL:	Determines the ecliptic scan angle of a sky location for a given spin axis position.
38.	NEPLOC:	Determines whether the North Ecliptic Pole is in a detector field-of-view for the MF.
39.	PHACC:	Decodes PHA data into field-of-view size, layer number, and channel number.
40.	FOVIEW:	Determines whether a sky location is in the field of view of a detector.
41.	NEPANG:	Computes the angle between the North Ecliptic Pole and detector axis.
42.	DBSPAN:	Driver for the analysis of accumulated Diffuse Background (DB) data.
43.	FACTRF:	Computes the factor used in correcting observed DB counts for non-x-ray events.
44.	SPCTRM:	Computes average PHA and DS counts for the DB analysis.

Table 2-1. HIPO Table of Contents (3 of 3)

45. DSHOM: Analyzes the homogeneity of DS data for the DB analysis.

46. CHISQ: Computes X^2 for the ratio of observed PHA DB counts to DB model counts.

47. RATENG: Forms ratios of PHA observed DB to model counts.

48. COMSPE: Compares NEP/non-NEP and Dark/Sun data for the DB analysis.

49. MDCDFI: Computer X^2 probabilities.

50. UERTST: Error analysis routine for X^2 probability calculation.

51. DBICON: Driver for the analysis of accumulated anisotropy analysis data.

52. DBISR: Does least squares fit to anisotropy data.

53. DSYMIN: Invents a symmetric matrix.

54. DCOVUP: Deletes rows and columns for matrix inversion.

55. DBIPRT: Controls printout of derived anisotropy parameters.

56. NSRSTA: Driver for the analysis of non-x-ray background data.

57. CALCON: Driver for the analysis of calibration data.

58. HEDCAL: Analyzes HED calibration data.

59. CALFIT: Performs least squares fit of calibration data to Gaussian line.

60. MEDCAL: Prepares MED calibration data and PHA data for calibration analysis.

61. MEDSET: Defines set of channels for use in least squares fit to MED calibration line.

62. PHACAL: Decodes PHA source rod data into channel/layer/ field-of-view for calibration analysis.

Calling Routine

Called Routine	CALCON	CALFIT	CHISQ	COMSPE	DBIANI	DBICON	DBISR	DBSPAN	DBSPEC	DSYMIN	EPHEM	ESRCES	FOVIEW	HEDCAL	MAIN	MDCDFI	MEDCAL	MFOV	NEPANG	NEPLOC	NXRMOD	NXRSTA	PROG1	PROG2	SCANGL	SINFOV	SPFLAG	SRCLOC	SUMOUT	SUPSUP
CALCON																													●	
CALFIT														●			●													
CHISQ								●																						
CLEAN															●															
COMCAL																								●						
COMSPE								●																						
CONVEC																		●		●	●							●		
CROSS																					●				●					
CVXYZ												●						●		●	●		●		●	●	●			
DBIANI																								●						
DBICON																													●	
DBIPRT						●																								
DBISR						●																								
DBSPAN																													●	
DBSPEC																								●						
DCOVUP										●																				
DIGIT															●															
DOT												●	●										●		●		●	●		
DSHOM								●																						
DSYMIN		●					●															●								
EPHEM																														●
ESRCES																							●							
FACTRF								●																						
FOVIEW																				●										
FREAD												●			●															
FWRITE								●																						
HEADER															●															
HEDCAL	●																													
INIT															●															
MDCDFI			●	●		●																●								
MEDCAL	●																													
MEDSET																	●													
MFOV																								●						
MODEC																								●						
MOUNT								●							●															
NEPANG					●																									
NEPLOC									●																					
NOMINL																								●						
NXRMOD																								●						
NXRSTA																													●	
PHACAL																	●													
PHACC									●																					
POSN															●															
PROG1															●															
PROG2															●															
RATENG								●																						
REMTIM																								●						
REWIND												●																		
SCANGL												●							●								●			
SCLEAN																								●						
SINFOV																														●
SPCTRM								●																						
SPFLAG																														●
SRCLOC																										●				
SUMOUT															●									●						
SUNMUM											●																			
SUPSUP																								●						
VERTST																●														
UNITV																		●			●				●					
UNLOAD															●															

Figure 2-3. Subroutine Cross-Reference Chart

COMMON AREA / USER ROUTINE	CALCON	CALFIT	CHISQ	CLEAN	CUMCAL	COMSPE	DBIANI	DBICON	DBIPRT	DBSPAN	DBSPEC	DIGIT	DSHOM	ESRCES	FACTRF	FOVIEW	HEDCAL	INIT	MAIN	MEDCAL	MEDSET	MFOV	MODEC	NEPLOC	NOMINL	NXRMOD	NXRSTA	PHACAL	PHACC	PNTWC	PROG1	PROG2	RATENG	SCANGL	SCLEAN	SPCTRM	SPFLAG	SUMOUT	SUP
ACCUM			●			●				●	●		●		●														●							●			
ANISOT							●	●																															
ANISTA							●	●																															
BLVALU																		●	●							●	●												
CALIB	●	●			●												●	●		●	●							●											
CATCOM														●				●								●					●							●	●
CHICOM			●							●																													
CHKTIM																															●	●						●	
COEFCM															●												●												
CONST									●					●				●								●					●								●
CONSTI																																		●					
CURREC				●	●		●				●			●								●	●	●		●			●	●	●	●			●		●	●	●
DEBCOM														●				●					●		●	●	●				●	●						●	
DETCOM																●								●						●									
DIGCOM																							●																
ERRSUN										●	●																												
FACTR			●												●			●																		●			
FCTCOM																		●														●						●	
FMOON				●																		●										●			●				
FOVCOM																●																							
INPARM																		●	●																				
MODCOM					●						●												●									●							
MODEL			●																														●						
MODOPT	●		●		●	●				●	●				●		●	●		●	●							●	●			●	●			●			
NAMCOM						●		●		●																							●						
NMNCOM																										●						●							●
NXRCOM															●											●	●												
NXRCOV																		●									●												
PDPCOM														●																									
PRINT						●				●				●				●																					
PRTSW				●			●											●	●			●					●					●			●				●
PUNCOM								●										●																					
RDOUT	●				●																																		
SAVDIG				●	●							●						●	●																●				●
SCLASS														●												●				●									
SPECTR			●			●																											●			●			
SSCLN							●				●																												●
SUMMY				●														●	●			●																	
TBECOM	●							●		●																	●				●							●	
TIME											●																												
UNCCOM																	●				●																		

Figure 2-4. Common Block Access Chart

2.3.2 Diffuse Background Module Design

The data accumulation routine for this module is DBSPEC. This routine ascertains whether the major frame data can be accumulated, i.e., the data must be in ROM1, RAM1, RAM9, or RAM10, must have no bit errors, each detector must be super-super clean and have C27=0, and have the chosen (or default) C45 and C46 modes. DBSPEC separates the data into the NEP or $\overline{\text{NEP}}$ categories through a call to NEPLOC which determines if the North Ecliptic Pole is in the detector field-of-view. This in turn calls FOVIEW. DBSPEC accumulates data into the proper arrays for DS data and calls PHACC to accumulate PHA data. PHACC unpacks the PHA data from COMMON block CURREC according to the RAM format and C45, C46 mode.

The analysis of the accumulated data begins in routine DBSPAN, which acts as the driver for analysis routines FACTRF, SPCTRM, DSHOM, CHISQ, RATENG, and COMSPE. These are called for each detector and, except for COMSPE, for each NEP array. DBSPAN also mounts and positions an output tape for storing the accumulated data, if the option is selected.

If specified by the user, FACTRF calculates the factor F_R, the ratio of the diffuse X-ray to non-x-ray counts for use in converting observed LFOV-SFOV counts to diffuse background counts corrected for the non-x-ray background. Otherwise F_R is set to 1.

SPCTRM calculates the average LFOV-SFOV DS counts per MF for separate layers 1 and 2. It also computes the average PHA counts for combined layers and errors.

DSHOM analyzes the homogeneity of DS data by calculating the variance from the mean, the error on the average, and the Poisson variance for each layer.

CHISQ computes the chi square, χ^2, for the ratio of PHA observed counts to model counts, where the model is a constant for each channel. MOCDFI computes the χ^2 probability of the fit and calls UERTST for error analysis, if necessary.

RATENG forms the ratios of PHA observed to model counts for each channel and also finds the error on the ratios.

Finally COMSPE computes a spectrum which is a weighted average between two comparison NEP arrays. A χ^2 test is performed to determine any difference in shape between the two spectra.

2.3.3 Non-X-Ray Background Module Design

NXRMOD accumulates data into appropriate arrays for the non-x-ray background analysis. For DS1 through 4 and for each detector (HEDs and MED), data is accumulated if it is super-super clean and obeys the coordinate restrictions discussed in Section 2.2.2.3. Average 5.12-sec DS counts per MF are computed each MF and accumulated along with the 16 parameters used to form elements of the normal equation matrices A and B. Since A is symmetric, only one side of the matrix need be computed and used to solve for the coefficeients of the 16-parameter fit. NXRMOD calls CVXYZ, CONVEC, CROSS, and UNITV to compute those parameters which involve coordinates.

NXRSTA performs the analysis of the accumulated data. DSYMIN is called to invert the symmetric matrix, after which the coefficients and errors , mean, variance about the mean, variance of the fit, and χ^2 for both are computed along with χ^2 probabilities using MDCDFI.

NXRSTA resets the array elements to 0 for use in the analysis of another interval.

2.3.4 Anisotropy Analysis Design

DBIANI accumulates super-super clean data within the galactic coordinates ranges specified in Section 2.2.2.3. Discovery Scalers 1 through 8 are used to find the average 5.12-sec LFOV-SFOV rates for four layers for each detector. NEPANG is called to find the angle between the North Ecliptic Pole and detector axis; this is used in computing the fit parameters and the A and B normal equation matrices used to solve for the fit coefficients.

DBICON is responsible for calling those routines which analyze the accumulated data for computing mean DS rates, the variance of the least squares fit, variance and χ^2

about the mean, χ^2 probability, and Poisson variance. DBISR is called to invert the A matrix, through a call to DSYMIN, and to solve for the coefficients of the fit. DBIPRT solves for the remaining parameters and errors of the fit discussed in Section 2.3.3.

DBICON also adds the A and B matrix elements of all three HED detectors together and calls DBISR and DBIPRT again to compute the coefficients of the combined fit and the analysis parameters. If the option is chosen, the matrices and accumulation for each detector can be punched on cards for archiving.

DBICON resets all arrays back to 0 so that another time interval can be analyzed if desired.

2.3.5 Calibration Module Design

Calibration word data is accumulated in subroutine COMCAL if the data has no bit errors, unchanging digital status, high voltage on and stable, and is uncontaminated by electrons. Data can be in ROM1, 2, or RAM1, 9 or 10. The calibration words contain the channel number and layer of a calibration event. For each event recorded by the calibration word, the accumulation array is incremented for the corresponding channel and layer array element. For calibration word data, C28 and the alpha threshold α must be 0 for the HEDs and 1 for the MED. The data must have the chosen or default C27 for the HEDs.

For the MED a separate PHA calibration histogram is accumulated if the source rod is in the field-of-view. In this case any C28 or α is acceptable, but C45, C46, C27 must remain unchanged during the accumulation of data and be as chosen or be the default values. The PHA MSB/LSB readout must be acceptable or data can not be accumulated.

CALCON is the main driver for the analysis routines, calling HEDCAL for the analysis of HED data and MEDCAL for MED data. CALCON punches cards containing accumulated calibration data, if the option is chosen.

HEDCAL defines the set of compressed and uncompressed channel histograms for either the 59.57-keV calibration line or the 29.08-keV. CALFIT performs the least-squares fit of uncompressed channel counts to the Gaussian model. CALFIT calls DSYMIN, which in turn calls DCOVUP to invert the symmetric matrix of the fitting procedure. CALFIT then computes the fit coefficients and errors, the standard deviation of the Gaussian line, mean channel of the line and error, and number of counts in the computed line.

MEDCAL finds the channel with the peak histogram counts and calls MEDSET to define the set of uncompressed channels. for the least squares fit to the Gaussian line, where the fit is done using the uncompressed channel number at the midpoint of the compressed channel. CALFIT is then called to complete the calibration word analysis.

If source rod calibration data has been accumulated, PHACAL is called to decode the PHA source rod data into layer, field-of-view, and channel, and to add together LFOV and SFOV data. Then MEDSER and CALFIT are called to define the uncompressed channel set and find the coefficients and analysis results.

SECTION 3 - USER'S GUIDE FOR PROGRAM FCUT-B

3.1 SYSTEM REQUIREMENTS

Program FCUT-B can be accessed and run on either the IBM S/360-91 or S/360-75 computer. It exists as an executable LOAD module in archives. The file is called ZBAL.FCUT.LOAD and the member is FCUT. The program can be run using the JCL in ZBDAL.LIB.FCUT(RUNFCT) or on punched cards. Core storage of 390k is required.

For running the program a MAX input tape, X-ray source catalogue in K3.ZBARS.SB018.XRSRC and NAMELIST input must be used. In addition, an output tape for diffuse background accumulations and card for calibration and anisotropy accumulations can be chosen.

3.2 INPUT DATA

Input parameters are specified through NAMELIST and FCUT. All cards having NAMELIST input have a blank in column 1. The first NAMELIST card has "&FCUT" in columns 2-6, followed by variables chosen to override default values. Each NAMELIST &FCUT ends with &END.

In the following example variables RA and DEC are specified:

```
&FCUT  RA=32.5, DEC=-70., &END
```

Variables may be continued on following cards.

The variables used in FCUT are:

Variable	Type	Default	Description
DTAPE	R*8	'XR0000'	MAX input tape volume serial number
NFILE	I*4	1	Starting file number of DTAPE
IREC	I*4	1	Starting record of NFILE
ISTART	I*4	3	Time interval flag: 1 = search for start of interval 2 = search for end of interval 3 = start of beginning of file
IDAY1	I*4	0	Start day of selected interval (used with ISTART = 1)
ITIM1	I*4	0	Start time (milliseconds) of day
IDAY2	I*4	0	End day of interval (used with ISTART = 1, 2 or 3)
ITIM2	I*4	0	Stop time (msec)
KNTINT	I*4	-2	When selecting time interval: 0 = process all frames -2 = process only clean frames When not selecting time interval: 0 = process all frames -1 = process no fill frames -2 = process clean frames -3 = process clean frames skipping first frame of file
I27CAL(4)	I*4	5	C27 flag for 4 detectors for calibration analysis 5 = choose C27 in first acceptable data on tape 0 = chosen C27 = 0 1 = chosen C27 = 1 (the following C flags use these values)

Variable	Type	Default	Description
I28CAL(4)	I*4	5	C28 flag for 4 detectors for calibration analysis
IC45DB(4)	I*4	5	C45 flag for diffuse background analysis
IC46DB(4)	I*4	5	C46 flag for DB analysis
I45CAL	I*4	5	C45 flag for PHA calibration analysis
I46CAL	I*4	5	C46 flag for PHA calibration analysis
IALCAL(4)	I*4	5	Alpha threshold flag for calibration analysis (values as for C flags)
IDSPFG	I*4	0	Time interval for DB analysis - multiple of 12 hours
IDANFG	I*1	0	Time interval for anisotropy analysis - multiple of 12 hours
INXRFG	I*4	0	Time interval for non-x-ray analysis - multiple of 12 hours
ICALFG	I*4	0	Time interval for calibration analysis - multiple of 12 hours
IDFSPA	I*4	0	0 = use only scan mode data for analyses of super-super clean data 1 = use point or scan mode data
IOUT	I*4	6	Unit for print output
IPUNCH	I*4	0	0 = no punched card output from anisotropy analysis 1 = punch cards for anisotropy accumulations and normal equation matrices

INXROP	I*4	0	0 = no print out of non-X-ray covariance matrix 1 = print out non-X-ray covariance matrix
IPRDBK	I*4	0	0 = no diffuse background printout of PHA counts for average of NEP arrays and X^2 per channel and DS for average of arrays 1 = print the above
QFRCAL	I*4	0	0 = set F_R in diffuse background analysis to 1 1 = calculate F_R using results of non-X-ray analysis
IPRSRC	I*4	0	0 = no printout of current source catalog 1 = printout current source catalog for present spin axis position
IPUNCL	I*4	1	0 = no punched card output from calibration analysis 1 = punch calibration accumulations and detector modes used
ITAPDB	I*4	0	0 = no tape output from diffuse background analysis 1 = write tape with diffuse background accumulations and detector modes used
NOUTNX	I*4	0	0 = no output of non-X-ray matrices to disk 1 = output non-X-ray onto disk unit 18

For each new MAX input tape, another &FCUT NAMELIST card is needed giving DTAPE, the tape volume number.

3.3 OUTPUT DATA

3.3.1 Tapes

If chosen, a tape containing diffuse background output can be written for the time interval analyzed. The output consists of interval beginning and end time, detector modes, and diffuse background PHA and DS accumulations. The tape is assigned to unit 15 and is 9 track, 1600 bpi with output format given in Appendix B.

3.3.2 Standard Printout

General printout consists of parameters used in NAMELIST FCUT, information from the MAX tape header for each file, and number of records read. For each MAX tape, a new NAMELIST FCUT is printed.

3.3.2.1 Calibration Printout

The calibration analysis output gives the time interval of the analysis followed by number of major frame, number of calibration events per detector, and number of major frames with source rod data.

For each detector, printout includes the C27, C28, and alpha threshold mode followed by the accumulated data for 64 channels for each of four ID modes. Layer 2 LFOV + SFOV (M2) results follow, with the peak channel for the two calibration lines, the channel peak and range for the line chosen for analysis, corresponding uncompressed channels and arrays of counts per channel, and channel numbers for uncompressed channels.

The normal matrices are printed, followed by computed fit coefficients, observed counts, standard deviation of the fit, mean channel and error of the Gaussian line, and computed events in the line.

Results for layer M1 (LFOV + SFOV, layer 1) are then printed. Similar results are output for the MED source rod data, when it is accumulated.

3.3.2.2 Anisotropy Printout

The total number of major frames accumulated for each detector, time interval, and symmetric matrix are printed. This is followed by the computed parameters for each DS pair including the mean 5.12-sec rate, time and Poisson variances, and χ^2 and probability for a constant rate (i.e. mean rate). In addition, the parameters A0, X1,Y1, etc, as given in Section 2.2.2.3 are printed along with their errors.

This is followed by the B matrix components and the computed coefficients C_o through C_4 of the least squares fit to the model.

Results for all four DS pairs are printed for each detector.

If all these HED detectors have accumulated data, results for the combined HED detectors are also given for the four DS pairs. In this case the parameters A0, X1, Y1, etc and errors of Section 2.2.2.3 are printed followed by the coefficients of the fit to the combined detector data.

3.3.2.3 Non-X-Ray Background Printout

If the option is chosen by the user (INXROP = 1 in the NAMELIST) the upper diagonal half of the symmetric co-variance matrix for each detector is printed. For each of the first four Discovery Scalers for each detector the following results are printed: the time interval of the analysis, number of major frames used in the analysis, mean 5.12-sec DS rate, "true" variance (variance from the mean), χ^2 for a constant (mean) rate and probability of a constant rate, variance of the least squares fit, χ^2 and probability for the fit. This is followed by the 16 fit coefficients and errors, where the coefficients are as given in Section 2.2.2.2.

Also listed after the detector results are the minimum, maximum, and average magnetic field strength, and McIllwain parameters found during the analysis interval.

3.3.2.4 Diffuse Background Printout

The interval for the analysis is printed along with the time interval number (the first interval is from days 250 to 258 and is incremented for approximately each 8-day period thereafter) and output tape number if the tape-option was chosen.

For each detector, the PHA mode of the data accumulation is given followed by results for each NEP array. This includes number of major frames accumulated, the DS LFOV-SFOV average, variance from the average, the square of the error on the mean (entitled "error") and Poisson variance for each layer. The χ^2 for a constant ratio to the model spectrum, number of degrees of freedom for the χ^2, and χ^2 probability of a fit to the model are given. If the probability is less than 0.05 or if the option is chosen by setting IPROBK, the average PHA LFOV-SFOV counts, the error on the average, ratio to model counts, and error in the ratio for each PHA channel are printed. After these results are given for each NEP array, the results of comparing NEP arrays are shown. This includes the χ^2 for the data of one NEP accumulation fit to another, the degrees of freedom, and χ^2 probability of the comparison. Where the probability is less than 0.05, the average of the NEP accumulations and χ^2 for each channel are printed.

3.3.3 Error Messages

'I/O ERROR ON RECORD 'XXX' FILE NUMBER' XXX ' MAX VOLUME'
XXX An I/O error has been encountered in reading a MAX tape record.

'INCORRECT OPTIONS SPECIFIED - REVIEW NAMELIST INPUT"
No analysis interval flag, ICALFG, IDANFG, INXXFG or IDSPFG has been set.

'***NAMELIST/FCUT IS NOT INPUT USED STOP*****'
This is a normal end-of-program message and simply means that all FCUT NAMELIST cards have been read in and no new input tapes are to be mounted.

'****I/O ERROR READING NAMELIST/FCUT/*****'
An I/O error has occurred in reading a NAMELIST card.

'*** Too many sources *****'
'SOURCE DELETED - 'XXX 'RA & DECL - 'XXX
'# OF THE SOURCE - 'XXX
More than 75 sources have been found for the current spin axis position; therefore the excess sources are not included in the current source catalog.

'I/O ERROR READING X-RAY SOURCE CATALOG FILE'
An error was encountered in reading the source catalog.

'**** NOT ENOUGH I/O TIME TO COMPLETE THE PROGRAM ****'
'TIME OF CURRENT RECORD - DAY -- MILLISECONDS OF DAY'
Not enough CPU or I/O time was requested for the run. Data up to the current record was accumulated and the analysis performed on this data

'*****INVALID ATTITUDE ******'
'FOR MAJOR FRAME TIME (DAY,MSEC)'
A major frame with zero attitude (x components of spin axis and look axis - 1.0) has been encountered.

'SUN/DARK FLAGS INCONSISTENT FOR'XXX' MAJOR FRAMES FOR DAY,MSEC'XXX' THROUGH' XXX

SUN flag from HSANPF different from ODATA(24) in COMMON block/CURREC/for X major frames

'ERROR NUMBER' N' FOR CHI SQUARE PROBABILITY'

N = 0 No error in X^2 probability

n = 129 X^2 <0 or Number of degrees of freedom <1

"*** I M S L (VERTST) TERMINAL'

'MDCDFI'

'(IER = 129)'

X^2 < 0 or number of degrees of freedom <1;

X^2 probability cannot be computed

'CHOSEN C28 ALPHA THRESHOLD INCORRECT FOR HED CALIBRATION ANALYSIS'

For HED calibration analysis C28 or alpha threshold chosen not to be 0 - no analysis possible for this HED.

'PEAK COUNTS AT LINE EDGE - NO FIT DONE'

No calibration fit possible for detector since calibration line skewed toward one side and has no Gaussian shape.

'CHOSEN C28 ALPHA THRESHOLD NOT ACCEPTABLE FOR MED CALIBRATION WORD ANALYSIS'

For MED analysis, C28 or alpha threshold chosen not to be 1

'CHOSEN PHA MODE UNACCEPTABLE FOR SOURCE ROD CALIBRATION ANALYSIS'

C45, C46 chosen to be 1, 0 or chosen C27 = 1 and either C45 or C46 not equal to 0 for source rod calibration analysis

'COMPRESSED CHANNELS 'x' TO 'x' TOO FEW FOR FIT'

Fewer than 3 compressed channels are in calibration line-no fit is done.

3.4 SAMPLE RUN JCL

```
//ZECALFC4 JOB (SEC1E21EEJ,1,AAC0C1,015005),BF3
//*TRANSLATE RUN DBK
//FCUT PROC
//GO EXEC PGM=FCL1,REGION=400K
//STEPLIB DD DISP=SHR,DSN=ZBDAL.FCL1.LOAD
//FT05F001 DD DDNAME=DATAS
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=7280,BUFNO=1)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265,BUFNO=1)
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265)
//SYSUDUMP DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,(1,1))
//*  MAX INPUT TAPE ON UNIT 10
//FT10F001 DD UNIT=(1600,,DEFER),DISP=(OLD,KEEP),LABEL=(1,NL),
//   DCB=(RECFM=FB,LRECL=15168,BLKSIZE=15168,DEN=3),
//   DSN=ZEFEE.MAX,TAPE,VOL=(PRIVATE,RETAIN,SER=MAXTAF)
//* X-RAY CATALOGUE ON UNIT 11
//FT11F001 DD DISP=SHR,DSN=K3.ZBDFA.SD018.XRSRC
//*  DIFFUSE BKG OUTPUT ON UNIT 15
//FT15F001 DD UNIT=(1600,,DEFER),DISP=(OLD,KEEP),LABEL=(1,NL),
//   DCB=(RECFM=U,BLKSIZE=12736,DEN=3),VOL=(PRIVATE,
//   RETAIN,SER=DBKTAF),DSN=ZBDAL.DBK.OUT
//*FT18F001 DD DSN=NULLFILE,DCB=(RECFM=F,BLKSIZE=80)
//FT18F001 DD DISP=SHR,DSN=ZBDAL.NX564.DATA
//FT19F001 DD DISP=SHR,DSN=ZBDAL.NX565.DATA
//FT20F001 DD DISP=SHR,DSN=ZBDAL.NX566.DATA
//*FT21F001 DD DISP=SHR,DSN=ZBDAL.NX24.DATA
//END PEND
//STEPA EXEC FCL1
//GO.DATAS DD *
 &FCUT CTAPE='XR0357',IDSPFG=16,IDFSPA=0,IPRDBK=1,ICALFG=16,IDANFG=16,
 INXRFG=0C,INXROP=1,NCLINX=0,IPUNCL=1,IPUNCH=1,DTAPDB='XR0113',ITAPCE=1,  &END
 IFILCE=1,NFILE=1,                                                      &END
 &FCUT CTAPE='XR0358',
//STEPE EXEC NOTIFYTS
```

APPENDIX A - DEFINITION OF CLEAN DATA

A.1 CLEAN DEFINITION

1. Clean data is defined for each detector to be:

   (a) Detector field-of-view excludes the Earth plus 100 km (test flag HEOCC2).

   (b) Detector high voltage is stable. The high voltage must be on (test flag HVFLAG) and be changing by less than 2.0 volts over the three major frames centered on the present data (test flag HVST).

   (c) There are no data transmission errors. This includes FILL data, (except when due to ROM/RAM toggle), IPD but errors, and block encoder errors (test HERRF).

   (d) Calibration source is not in field-of-view for LEDs and MED (test digital status).

2. Clean Flag is defined for each detector:

2**0	=	LED 1
2**1	=	LED 2
2**2	=	HED 1
2**3	=	HED 2
2**4	=	MED
2**5	=	HED 3

where: bit = 1 = clean
bit = 0 = not clean

A.2 SUPER CLEAN DEFINITION

1. Superclean data is defined for each detector to mean:

   (a) Detector data is CLEAN.

   (b) Detector field-of-view excludes the Moon.

   (c) Field-of-view excludes the Earth plus 100 km (test flag HEOCC2).

   (d) All 1.28-second Discovery Scaler rates are less than 256; i.e., no LSB overflows.

   (e) Rate in the first four Discovery Scalers is constant as determined by the following criteria:

      (i) For each 1.28-second sample, add first four Discovery Scalers.

      (ii) For 32 entries, calculate the actual variance, μ_2 and the statistical variance, $\sigma^2 = N$ (1.28 sec.)

      (iii) Data is constant if $\mu_2 \leq 1.3\ (\sigma^2)$

2. Superclean Flag is defined for each detector:

2**0	=	LED 1
2**1	=	LED 2
2**2	=	HED 1
2**3	=	HED 2
2**4	=	MED
2**5	=	HED 3
where :		bit = 1 = superclean
		bit = 0 = not superclean

A.3 SUPER-SUPER CLEAN DEFINITION

1. Super-super clean is defined for each detector to mean:

   (a) Data is super-clean.

   (b) Detector digital status is unchanging during the major frame.

   (c) No sources are in the detector field-of-view.

   (d) No electron contamination is present.

   (e) The detector is in nominal mode.

APPENDIX B - DIFFUSE BACKGROUND OUTPUT TAPE FORMAT

The diffuse background output tape is a 9-track 1600 bpi NL tape with RECFM=U, BLKSIZE=12376 written by the FT10 library routine FWRITE. Where the option is chosen, each diffuse background run outputs a file containing the following three records. Variables are I*4 except for Record 1.

Record 1 - contains 96 bytes of information on the start and end times of the analysis.

Bytes 33-40 contain the start time and bytes 81-88 contain the end time, both are R*8 words.

Record 2 - contains C45 and C46 flags for the analysis and total of 96 bytes.

Variable	Bytes	Description
IC45DB(4)	41-56	C45 flag for HED1, HED2, MED, and HED3
IC46DB(4)	57-72	C46 flag for HED1, 2 MED, HED3

Record 3 - contain accumulated DB data of 12736 bytes.

Variable	Description
NPHA(2,64,4,4)	Accumulated PHA data for 2 fields-of-view (SFOV, LFOV), 64 channels, 4 detectors, 4 NEP arrays
NDS(2,2,4,4)	Accumulated DS data for 2 layers (1, 2), 2 FOVs, 4 detectors, 4 NEP arrays
NDSSQ(2,4,4)	Square of DS LFOV-SFOV rates for 2 layers, 4 detectors, 4 NEP arrays
NPHASQ(64,4,4)	Square of PHA LFOV-SFOV counts for 64 channels, 4 detectors, 4 NEP arrays

- Standard Layer 2 Event Definition

  Byte 27, bits 6-4 = 0
- Standard Layer 1 PHA Window Definition

  Byte 32, bits 7-4 = 0
- Standard Layer 2 PHA Window Definition

  Byte 28, bits 5-4 = 0
- Standard Discover Scaler Definition for DS 5 and 6

  Byte 28, bits 7 = 1
- Standard Discovery Scaler Definition for DS 7 and 8

  Byte 30, bit 3 = 1
- 5.12-Second DS MSB Readout Time

  Byte 32, bit 3 = 0 in Detector status

  bit 3 = 0 in DPU status

For those formats (ROM1, RAM1, RAM9, and RAM10) containing PHA data, the following states were also defined for each detector:

- PHA Fixed Dead Time Selected

  Byte 31, bit 1 = 0
- Normal PHA MSB and LSB readout times

  Byte 32, bits 1-2 in Detector status

  bits 1-2 in DPU status

Standard Times: ROM1 - MSB = 40 sec
LSB = 10 sec, bits = 0
RAM1 - MSB = X
LSB = 40 sec, bits = 11
RAM10- for HED2 MSB, LSB = 40, bits = 11
for others MSB, LSB = 40,10
bits = 00
RAM9 - MSB = 40, LSB = 10 sec, bits= 00

For these formats with Delta-T computer data, (ROM2, RAM1, RAM9, RAM10) the following nominal detector states are defined:

- 80 millisecond Multiscaler mode selected
  Detector Status Byte 31, bits 7-4 = 0X00
  DPU Status bits 7-4 = 1X00
- Sum of DS 1-4 rate selected
  Byte 33, bits 3-0 = 0

In RAM10 format only HED2 has this data.

All other configurations are considered non-standard. These include the formats labeled RAM11 - RAM15, as well as data with configurations not matching the standard for the format.

The byte and bit locations specified above correspond to the internal R. Rothschild documentation.

APPENDIX C - NOMINAL STATUS DEFINITION

Standard experiment states, i.e., nominal experimental command states, are defined for each of the five generally used configurations. Each configuration corresponds to a standard telemetry format. These standard formats are ROM1, ROM2, RAM1, RAM9, and RAM10.

For all these configurations, the nominal state is defined to have the following status:

Experimental Status:

- MED Calibration Rod out of the field-of-view
  Byte 14, bit 3 = 0
- HED1, HED2, and HED3 Veto Propane pressure state.
  Byte 17, bit 1 = 0 (pressurized)
  Byte 17, bit 0 = 1 (no pressure)
  Byte 18, bit 7 = 0 (pressurized)

Detector Status (For each detector)

- Low Voltage Power ON — Byte 25, bit 6 = 1
- TPG Power OFF — Byte 25, bit 5 = 0
- High Voltage Power ON — Byte 25, bit 4 = 1
- Standard Layer Thresholds
  Byte 26, bit 7-0 = 0
- Standard C28 state, for MED Byte 27, bit 7 = 0
  for HEDs Byte 32, bit 0 = 0
- Standard C27 Mode — Byte 29, bit 4 = 0
- Standard Veto Thresholds
  Byte 27, bit 3-0 = 0
- Standard M1, M2 Thresholds
  Byte 29, bits 3-0 = 0
- Standard Layer 1 Event Definition
  Byte 29, bits 7-5 = 0

CSC

COMPUTER SCIENCES CORPORATION

Major Offices and Facilities Throughout the World